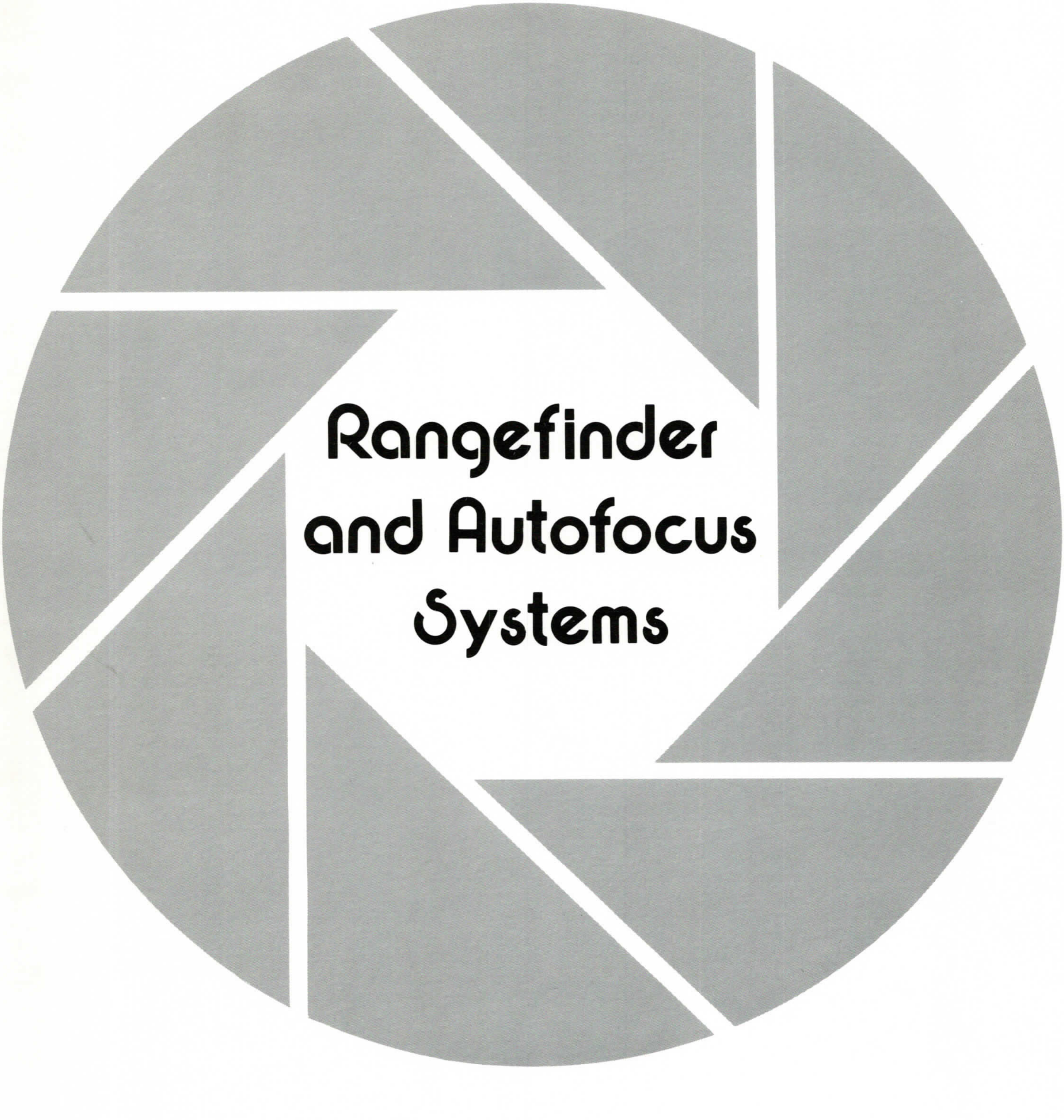
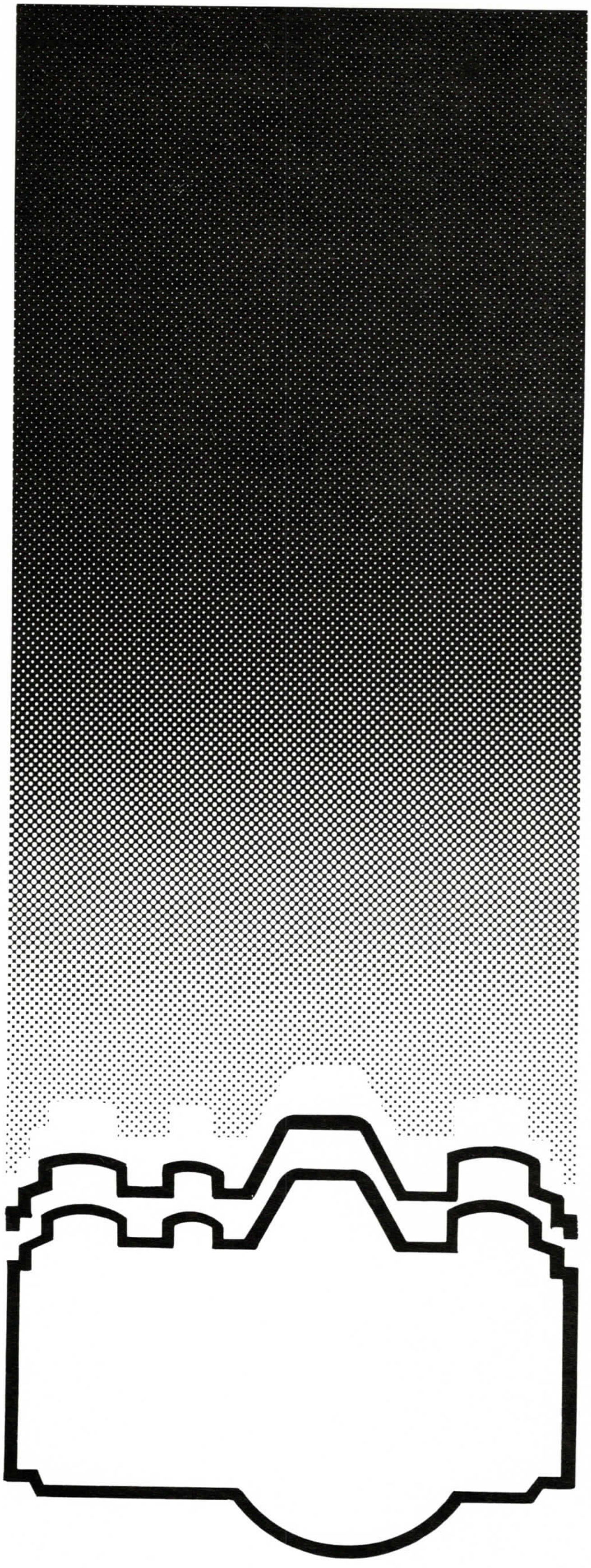


Rangefinder and Autofocus Systems



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Rangefinder and Autofocus Systems

contents

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Rangefinder and Autofocus Systems

THE RANGEFINDER PRINCIPLE

In your lesson "The Camera and Its Variations," you learned the purpose of the rangefinder—to measure the distance to the subject. Typically, the rangefinder calculates the subject distance as you turn the focusing ring of the lens. The rangefinder then tells you when you've set the lens for proper focus.

Most optical rangefinders show you two images of the subject, Fig. 1. You then turn the focusing control until the two images superimpose (come together). When you see only one image, you've focused the lens according to the subject distance.

The viewfinder of a rangefinder-type camera normally has a rectangle or circle in the center, Fig. 2. Within this rangefinder rectangle, you can see the two images:

1. the **primary image**—the image of the subject viewed directly through the viewfinder
2. the **secondary image**—a duplicate of a portion of the primary image (the portion within the rangefinder rectangle).

As you focus the lens, the primary image in most rangefinders doesn't move. Rather, the secondary image moves closer to or further from the primary image. The secondary image, projected optically into the viewfinder, moves closer to the primary image as the lens moves closer to the proper distance setting. At the proper distance setting, the secondary image superimposes on the primary image.

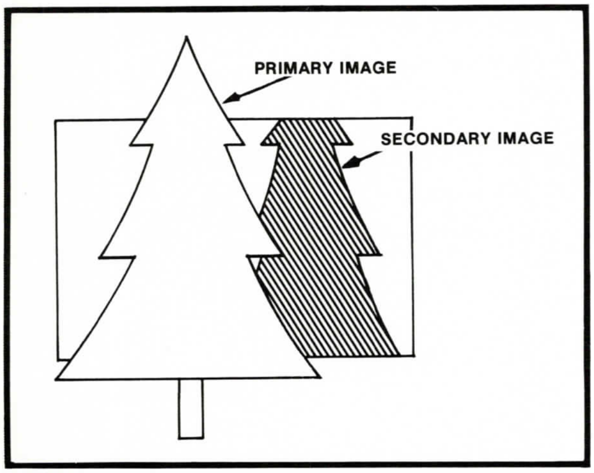


FIGURE 1

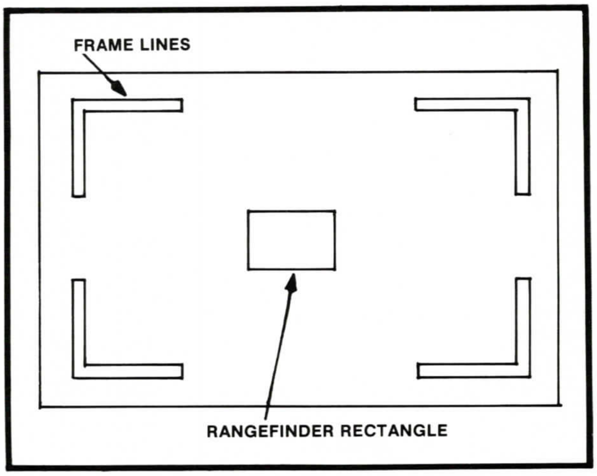


FIGURE 2

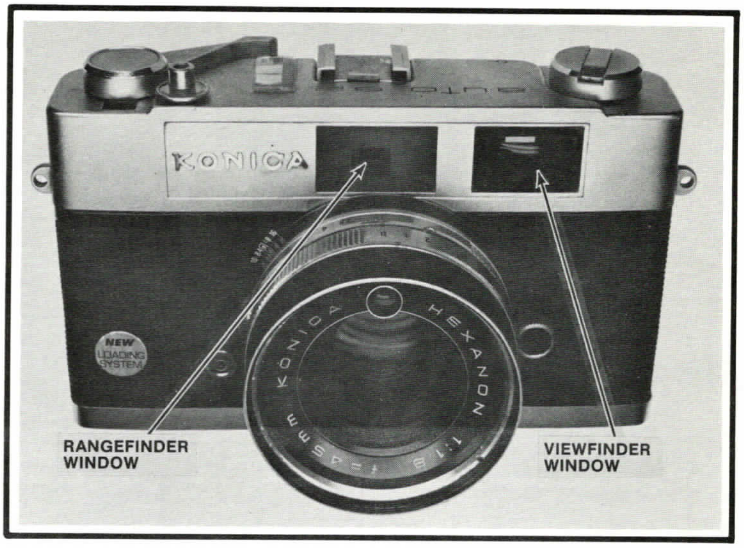


FIGURE 3

The rangefinder determines the subject distance by looking at the subject from two separated positions. Note the two windows at the front of the camera—the viewfinder window and the rangefinder window, Fig. 3. The rangefinder sights through both windows at the same time.

Because of the separation between the two windows, the lines of sight converge, Fig. 4. The angle at which the lines converge depends on the subject distance. For a closer subject, the angle increases (indicated by the dashed line in Fig. 4). The angle decreases for a more distant subject. Consequently, the angle provides a measure of the subject distance.

You've probably studied the principle before—it's the same as the principle for specifying a triangle. If you know two of the angles and the side between those angles, you can calculate the other parts, Fig. 5. The rangefinder calculates distance A, Fig. 5—the distance to the subject—by first determining angle b.

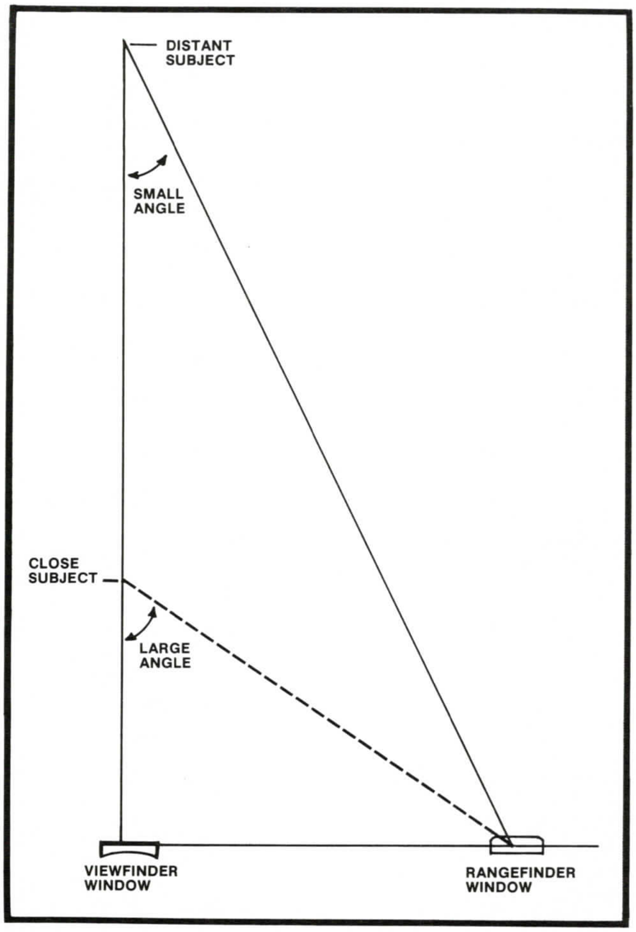


FIGURE 4

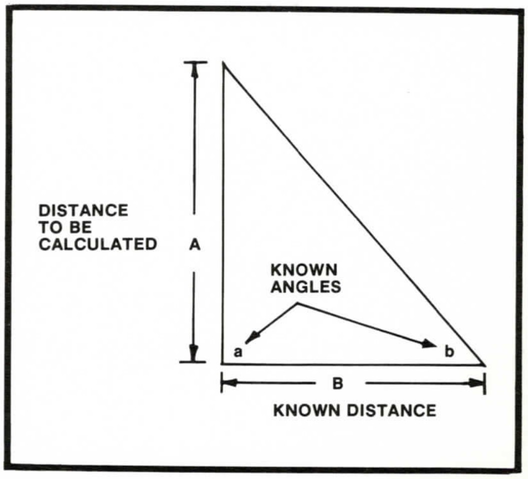


FIGURE 5

THE MOVABLE-MIRROR RANGEFINDER

One type of rangefinder uses a movable mirror to determine the unknown angle. Fig. 6 shows the design. The movable mirror and a semisilvered mirror sit on the base line of the rangefinder—a known distance apart. This distance, the **base length** of the rangefinder, relates to side B in Fig. 5.

When you look through the viewfinder, you see the subject through the semisilvered mirror, Fig. 6. The semisilvered mirror serves as a **beamsplitter**—its partially silvered side both transmits and reflects light.

The silvered side of the beamsplitter faces the movable mirror, Fig. 6. Light entering the rangefinder window strikes the front, fully silvered surface of the movable mirror. The movable mirror now reflects the light to the partially silvered surface of the beamsplitter. And the beamsplitter reflects the light into the viewfinder.

Two images therefore appear in the viewfinder. One is the primary image, the image viewed directly through the beamsplitter, Fig. 1. The other is the secondary image, the image reflected through the system by the mirrors.

The two images superimpose if the reflected light follows the base line, Fig. 6. Light parallel to the base line strikes the beamsplitter at a 45° angle. Consider that you're focusing on a subject that's an infinite distance from the lens. Remember, light rays coming from infinity are parallel to one another, Fig. 7. To superimpose the images, the movable mirror must sit at a 45° angle to the base line.

Why? The angle of incidence (the angle that the light strikes the mirror) equals the angle of reflection, Fig. 7. So, at an angle of 45°, the movable mirror reflects the light along the base line.

When the subject moves closer to the camera, the light rays diverge, Fig. 8.. Now the reflected ray no longer follows the base line. Rather, it takes the path shown in Fig. 8. And the secondary image moves away from the primary image.

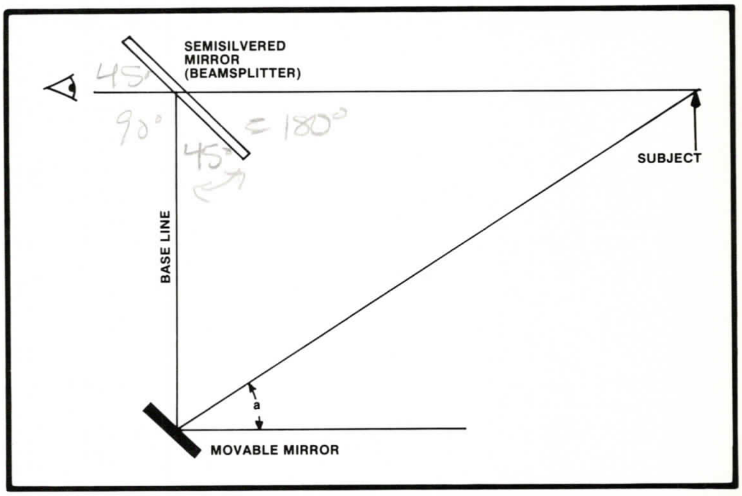


FIGURE 6

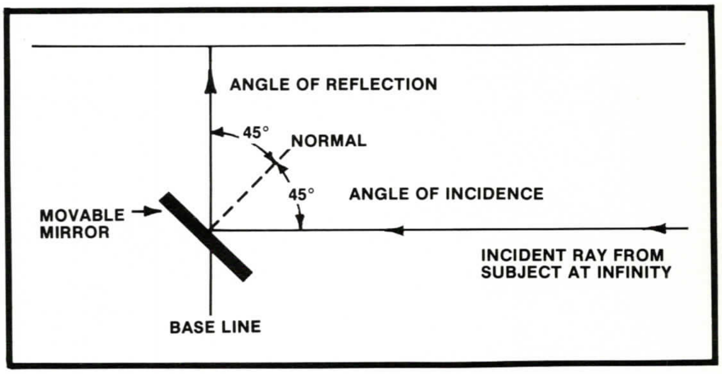


FIGURE 7

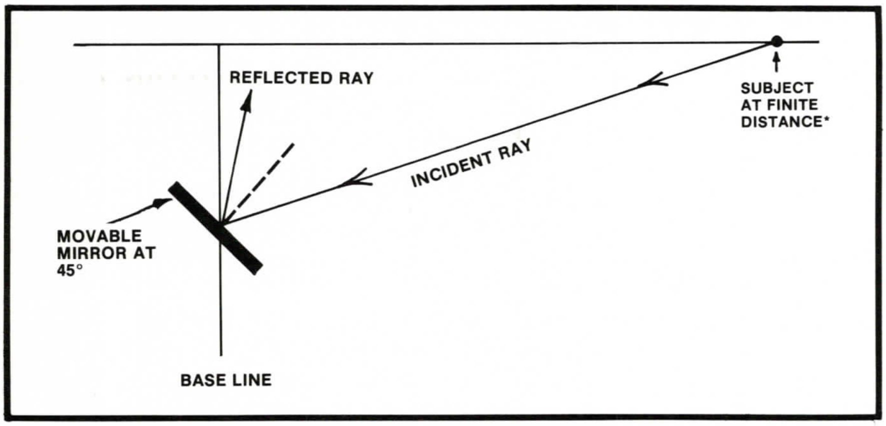


FIGURE 8

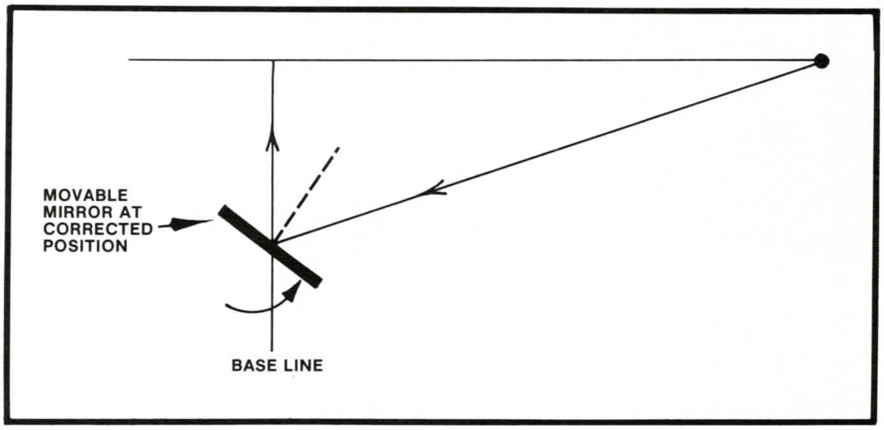
*finite distance (pronounced figh-night) = a distance closer than infinity.

You can once again bring the images together by changing the angle of the movable mirror. Turning the focusing ring of the lens swings the mirror as shown in Fig. 9. As the mirror swings counterclockwise, it brings the reflected ray toward the base line. The images superimpose when the reflected light and the base line coincide, Fig. 9.

The angle of the movable mirror in Fig. 9 relates directly to the subject distance. If the subject moves closer to the camera, angle a in Fig. 6 must decrease to superimpose the images. The angle must increase if the subject moves further from the camera. The rangefinder simply finds the unknown angle by superimposing the images. It then knows the distance to the subject—side A of the triangle in Fig. 5.

Accuracy in a rangefinder depends on how well the system can distinguish between different distances. For example, can the rangefinder distinguish between a subject that's 15 feet away and one that's 20 feet away? The accuracy depends on the base length—the longer the base length, the more accurate the rangefinder. With a longer base line, the movable mirror must swing a greater distance for the same change in subject distance.

FIGURE 9



TEST-YOURSELF QUIZ #1

1. With a rangefinder, you view the PRIMARY image directly through the viewfinder; the SECONDARY image is projected optically into the viewfinder.
2. As the subject moves closer to the camera, the angle between the subject and the rangefinder window
   A. increases
   B. decreases
   C. remains the same
3. To superimpose the secondary image of a subject at infinity, the angle between the base line and the normal of the movable mirror must be
   A. 45°
   B. less than 45°
   C. more than 45°
4. As the subject moves closer to the camera, the angle between the base line and the normal of the movable mirror must DECREASE (increase, decrease) to superimpose the images.

COUPLING TO THE LENS

To cross-couple the rangefinder, the moving rangefinder component must couple to the focusing mechanism of the lens. Most cameras use the **cam-and-lever system**. Here, a spring-loaded lever attaches to the movable rangefinder component, Fig. 10.

The cam in Fig. 10 attaches to the back of the lens assembly. As the lens moves in, the cam also moves in. The cam then pushes back the rangefinder lever—against the spring tension. When you focus to a closer distance, the cam moves toward the front of the camera. The spring-loaded rangefinder lever follows the cam and moves the mirror in the opposite direction.

In many cameras, a pin couples the rangefinder lever to the rangefinder cam. One end of the pin rides against the cam; the other end comes against the lever. When you remove the rangefinder assembly, the pin may be loose. Be very careful to avoid losing the pin—the length of the pin is critical in the rangefinder accuracy.

SERVICE NOTE

Why not simply attach the rangefinder lever directly to the lens? It may seem that you could simplify the linkage by eliminating the cam. But the movement of the lens may be greater or less than the movement of the mirror. And the amount the lens moves to change the focus varies at different distances. It may require a large amount of lens movement to change the focus from 3 feet to 4 feet—and a relatively small amount of lens movement to change the focus from 30 feet to infinity. The cam assures that the images superimpose at the same time as the lens comes into focus.

A different lens focal length then requires a different cam shape. If the camera accepts interchangeable lenses, there must be a way to change the cam for each lens.

With most interchangeable-lens systems, each lens includes its own cam. The cam may be formed on the back of the lens helicoid, Fig. 11. When you install the lens, the cam comes against a roller that reaches inside the lens opening. This roller—the cam follower—attaches to the end of the rangefinder lever.

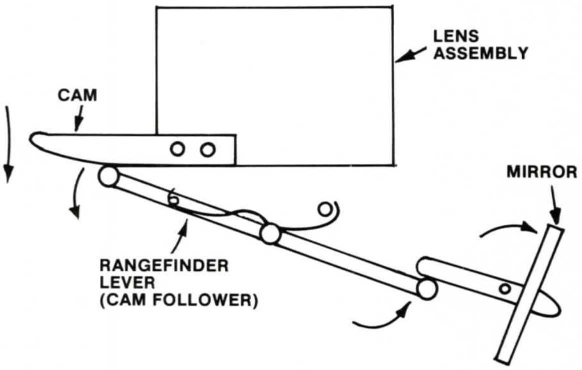


FIGURE 10

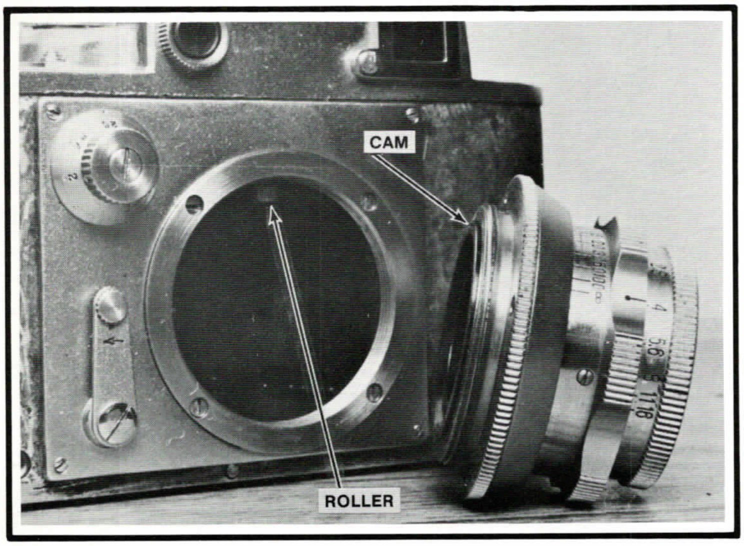


FIGURE 11

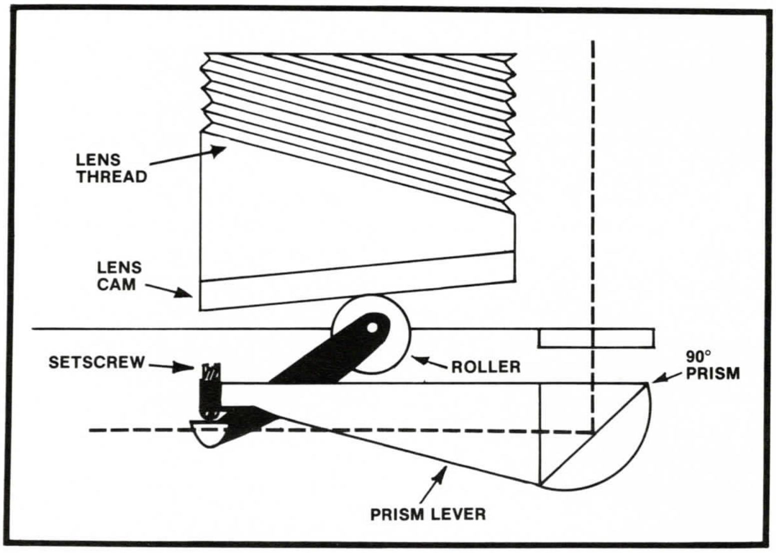


FIGURE 12

REMEMBER RUG + TRUCK

"QUALITY" PRISM

Fig. 12 shows a typical coupling system. Notice that the system in Fig. 12 uses a 90° (right-angle) prism rather than a mirror. The 90° prism serves the same purpose—it reflects the secondary image along the base line to the beamsplitter. But the prism has an advantage over the mirror—the prism doesn't require a silver coating on the reflecting surface. Total internal reflection causes all of the light to be reflected.

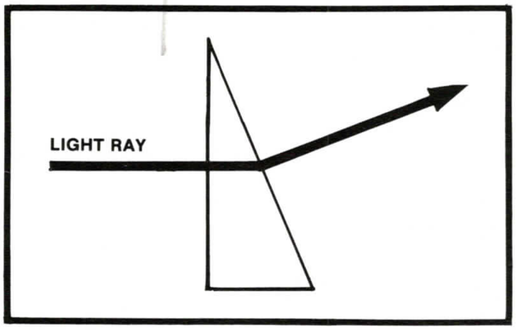


FIGURE 13

REFRACTING-LIGHT SYSTEMS

You've seen that the movable mirror or prism serves to reflect the light along the base line. It's possible to gain the same results by refracting—rather than reflecting—the light. A rangefinder may then use a lens or a prism wedge to change the direction of the light ray.

Fig. 13 shows how a prism wedge can redirect the light. Notice that the light ray changes direction after passing through the wedge. Why? The side of the light ray that first re-enters the air speeds up sooner than the other side.

By using two such wedges, the rangefinder can bend the light ray as needed to superimpose the images. The two wedges, Fig. 14, rotate with respect to one another as you focus the lens. Working as a team, the two wedges then control the path of the light entering the rangefinder system.

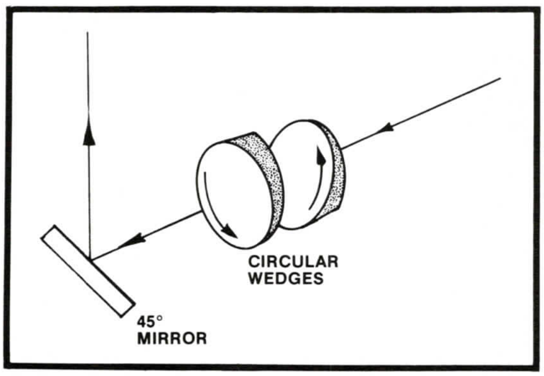


FIGURE 14

The 45° reflecting surface inFig. 14 doesn't move; it always remains at the 45° angle to the base line. So, to superimpose the images, the wedges must control the light that's incident to the mirror surface. If the incident light is at a 90° angle to the base line, the reflected light follows the base line.

At infinity, the wedges sit as shown in Fig. 15. Notice that the thin edge of one wedge is adjacent to the thick edge of the other wedge. Although the first wedge refracts the light, the second wedge cancels the effect. And the light strikes the mirror at a 90° angle to the base line

But the light from a closer subject strikes the wedges at an angle. Now, to keep the light entering the rangefinder at a 90° angle to the base line, the wedges must rotate.

To rotate the wedges, the rangefinder uses a different type of linkage system—**geared linkage**, Fig. 16. The focusing gear in Fig. 16 couples both to the lens and to the wedge prisms. As you turn the focusing gear to focus the lens, the prisms rotate to superimpose the images.

The rotating-wedge rangefinder provides a large amount of image displacement for a small amount of mechanical movement. However, the cost of the system has limited the rotating-wedge rangefinder to expensive cameras. Modern rangefinder systems, used mostly in relatively inexpensive cameras, normally have the simpler cam-and-lever designs.

Yet most of the current rangefinders apply the principle of light refraction. A movable refracting element sits within the rangefinder—between the beamsplitter and the fixed 45° mirror, Fig. 17. The **movable-lens rangefinder** then corrects the light path along the base line.

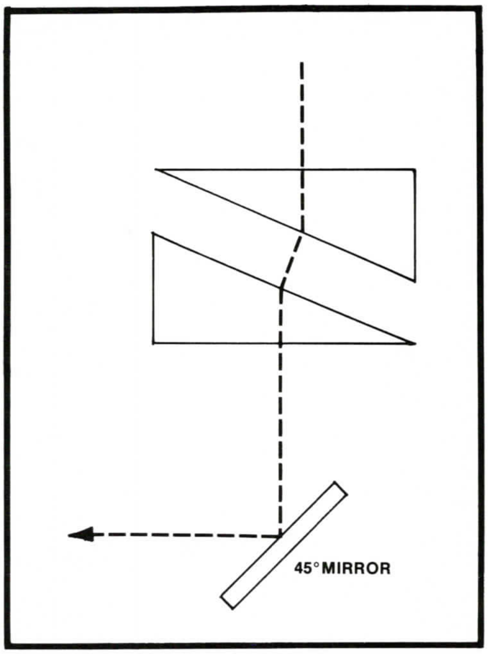


FIGURE 15

WEDGE PRISMS SET FOR SUBJECT AT INFINITY

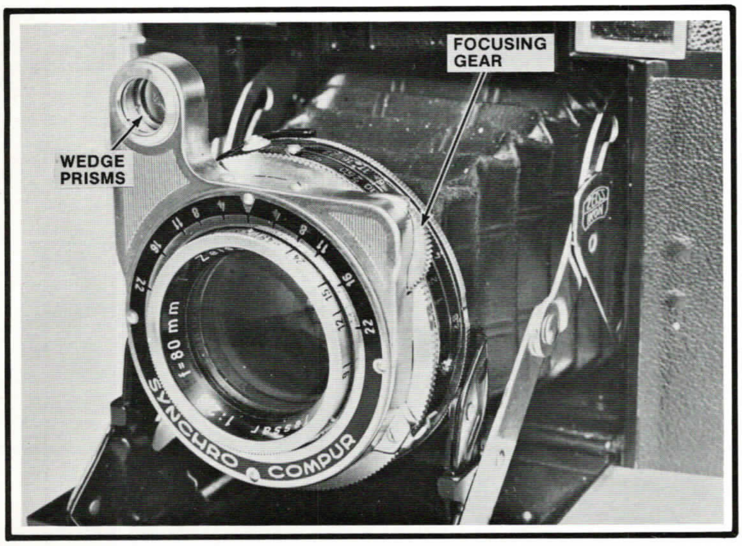


FIGURE 16

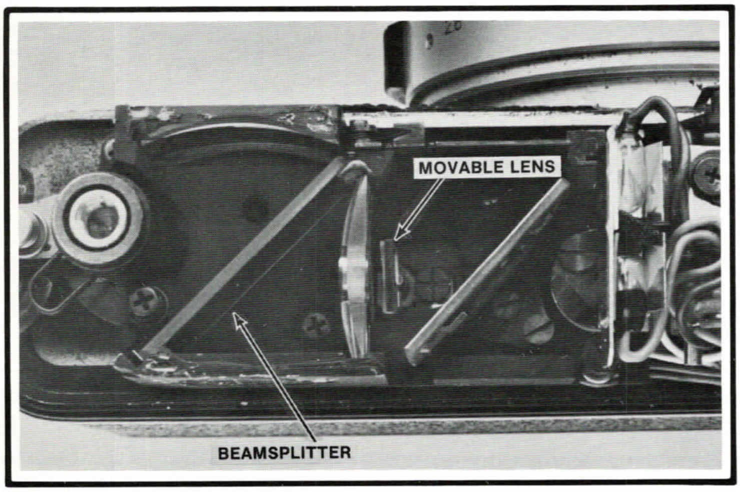


FIGURE 17 YASHICA ELECTRO-35

For simplicity, we've shown the movable lens as an optical flat in Fig. 18. Consider first a subject at infinity. The light reflected from the fixed 45° mirror now follows the base line. So, to superimpose the images, the refracting element must not displace the secondary image. When you focus the lens to infinity, the refracting element moves to the position shown in Fig. 18.

If the subject isn't at infinity, the light reflected from the 45° mirror no longer follows the base line. The refracting element must then correct the light path to superimpose the images. As you focus to closer distances, the movable refracting element swings toward the front of the camera, Fig. 19. The images superimpose when the refracting element causes the light to strike the beamsplitter at a 45° angle.

Now the position of the refracting element relates to the subject distance. A cam-and-lever linkage system, just like the systems for movable-mirror rangefinders, positions the movable lens.

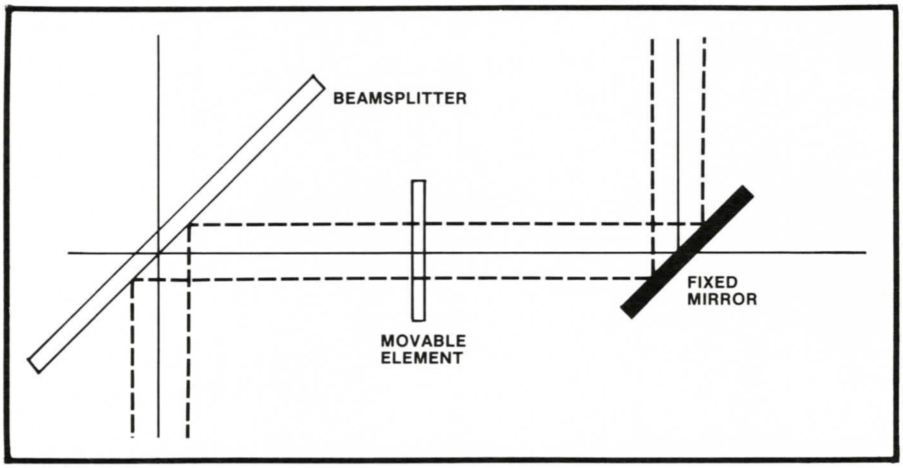


FIGURE 18

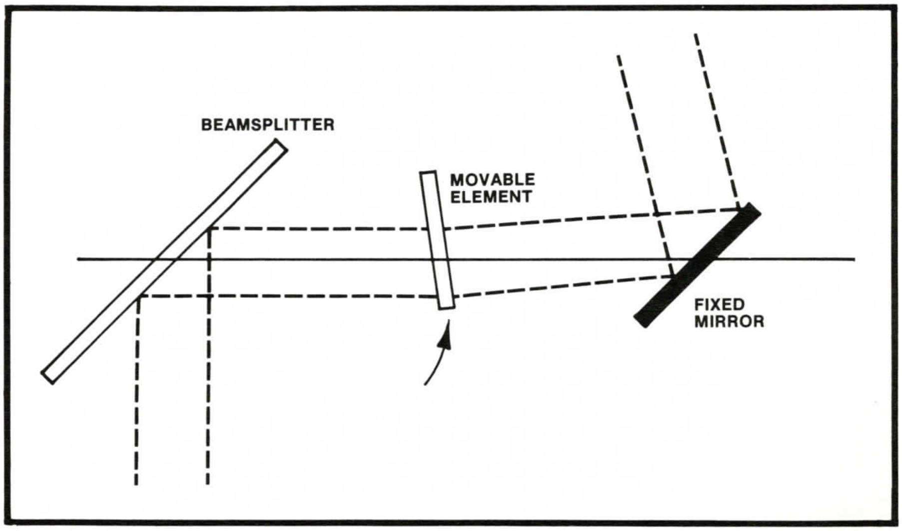


FIGURE 19

COMPLETE RANGEFINDER SYSTEMS

A rangefinder normally projects more than the secondary image into the viewfinder. It also projects the frame lines, Fig. 2. With most systems, the frame lines provide parallax compensation—they move as you focus the lens.

Fig. 20 shows the optical diagram of the rangefinder pictured in Fig. 18. You've seen that the Yashica rangefinder uses a movable lens. Light forming the secondary image passes through the movable lens and through a hole in the center of a condenser lens.

The condenser lens is part of the optical system for projecting the frame lines into the finder. You can see the frame-line mask at the front of the rangefinder, Fig. 21. Light passing through the illuminating window, Fig. 20, also passes through the slots in the frame-line mask.

A mirror behind the frame-line mask, Fig. 20, reflects the illuminated frame lines through the condenser lens and into the finder. But the frame-line mirror doesn't interfere with the secondary image. The light reflected from the fixed 45° mirror passes through an unsilvered rectangle at the center of the frame-line mirror.

Turning the focusing ring of the lens moves both the movable lens and the frame-line mask, Fig. 20. A cam at the back of the lens assembly moves the rangefinder lever, Fig. 22—a typical cam-and-lever linkage system. The rangefinder lever carries the movable lens. Also, the rangefinder lever couples to a tab on the spring-loaded frame-line mask, Fig. 21. So, as the rangefinder lever shifts the movable lens, it also positions the frame-line mask to provide parallax compensation..

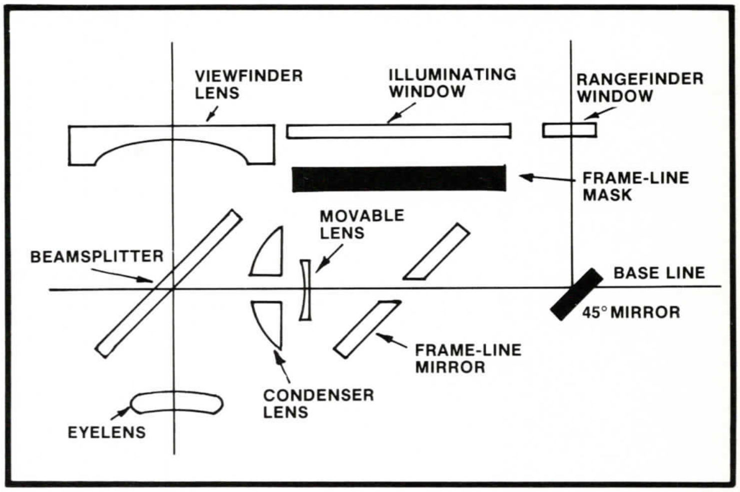


FIGURE 20 YASHICA RANGEFINDER

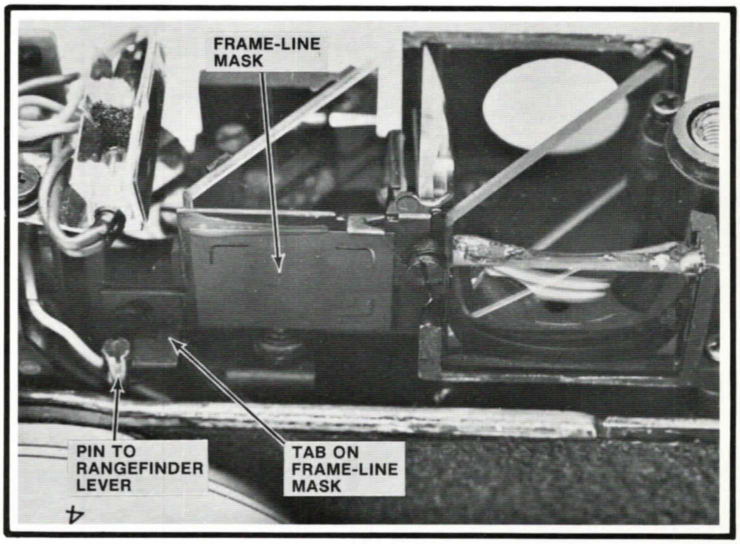


FIGURE 21 YASHICA ELECTRO-35

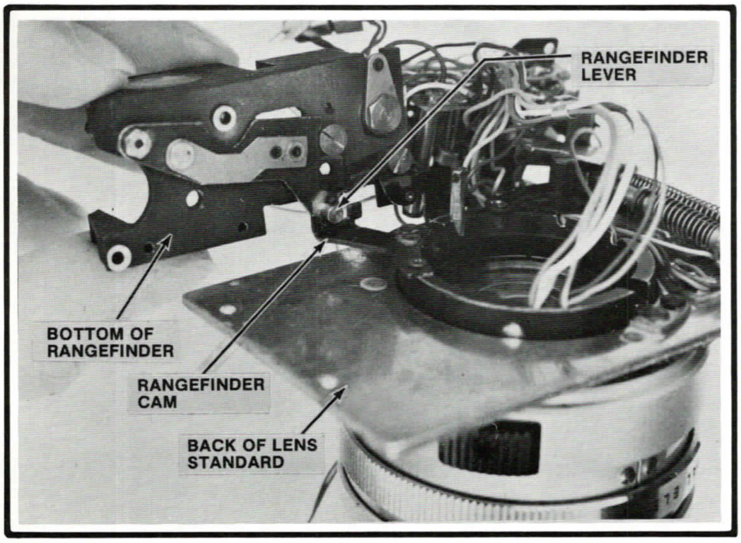


FIGURE 22 YASHICA ELECTRO-35

In the Konica movable-mirror system, Fig. 23, the secondary image passes through the frame-line mask. The frame-line mask has two sections—a movable section and a fixed section. A rectangular cutout in the fixed section, Fig. 24, serves as the rangefinder window.

Focusing the lens shifts the movable section of the frame-line mask. The area enclosed by the frame lines then changes in size—a smaller area for a closer focusing distance.

Both the Yashica and Konica rangefinders also project the exposure-meter information into the finder. The Yashica Electro-35 has two lamps which appear as arrows above the frame lines; the arrows tell you which way to turn the diaphragm-setting ring. In the Konica, the scale mirror, Fig. 23, projects the image of the exposure-meter scale and needle into the finder.

The reflected image passes above the frame-line mirror and condenser lens, Fig. 23. You then see the image just above the frame lines at the top of the finder.

Most of the rangefinders in current 35mm cameras are similar to the ones we've discussed. But there is a modern camera that uses a more sophisticated rangefinder—the Leica. We'll cover the Leica rangefinder later in this assignment.

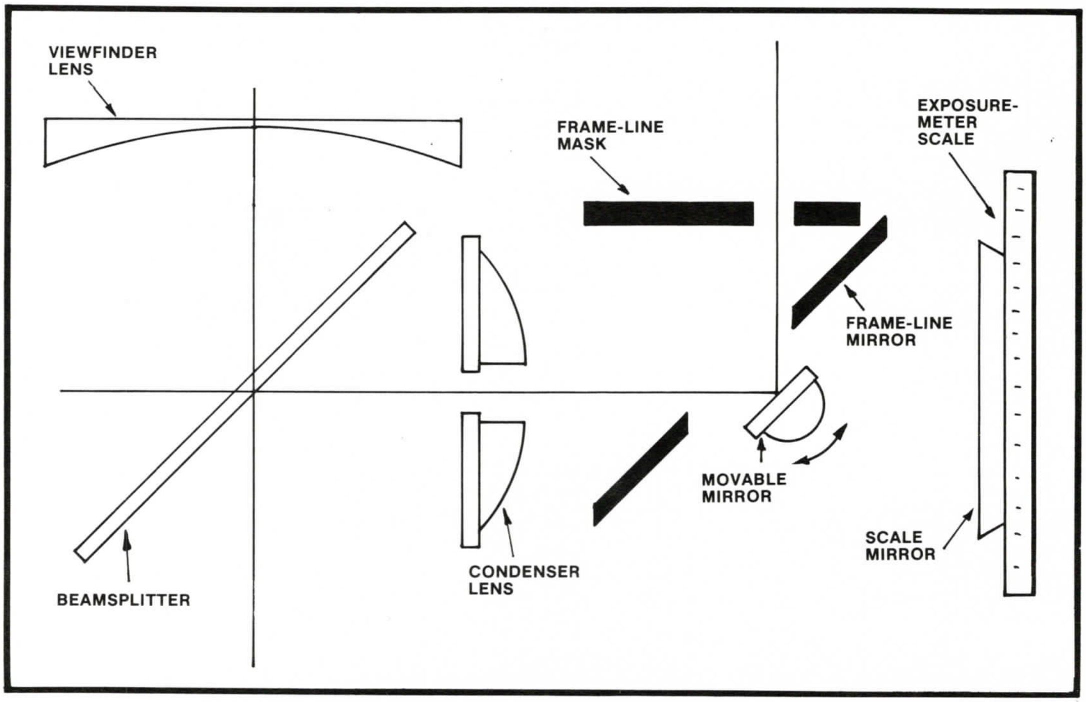


FIGURE 23 KONICA RANGEFINDER

TEST-YOURSELF QUIZ #2

1. A movable-mirror rangefinder normally uses
   A. cam-and-lever linkage
   B. geared linkage
2. The refracting element in a movable-lens system is located
   A. in front of the 45° mirror
   B. between the beamsplitter and the eyelens
   C. between the beamsplitter and the 45° mirror

3. To superimpose the image of a finite subject, the movable lens swings
   A. toward the front of the camera
   B. toward the back of the camera
   C. closer to the 45° mirror
   D. closer to the beamsplitter
4. A movable-lens rangefinder normally uses
   A. geared linkage
   B. cam-and-lever linkage
5. As you focus the lens, the rangefinder often provides parallax compensation by moving the FRAMELINE MASK.

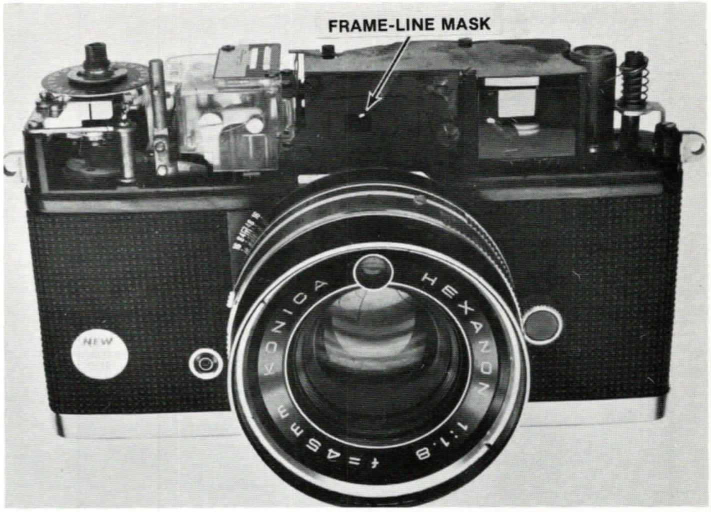


FIGURE 24

RANGEFINDER REPAIRS

When you work on a rangefinder-type camera, you'll usually have to adjust the rangefinder accuracy. But there's little else that goes wrong with rangefinders. Occasionally you'll find that a mirror or beamsplitter has come loose from its mount—probably the result of impact. If the optic hasn't broken, you can recement it to the mount.

What if the optic is damaged? Your repair then depends on the particular camera. It may be possible to obtain the optic as an individual replacment part. However, in most cases, individual rangefinder parts aren't available. And you'll have to replace the complete rangefinder assembly.

The rangefinder normally comes out of the camera as a complete unit, Fig. 25. Even though you may not be repairing the rangefinder, you'll usually have to remove the unit to disassemble the camera. Typically, two or three screws hold the rangefinder assembly, Fig. 25. You may have to remove a dust cover at the top of the rangefinder to reach the screws. The dust cover may also be held by screws. Or it may be cemented to the rangefinder assembly.

Remember that some designs use a pin to couple the rangefinder lever to the rangefinder cam. Be careful as you lift out the rangefinder—the pin may be loose. The pin usually passes through a hole in the front plate of the camera.

On reassembly, hold the rangefinder lever against its spring tension as you seat the rangefinder. The end of the rangefinder lever must fit to the back of the rangefinder cam, Fig. 25. In other designs, the spring-loaded lever sits to the back of an intermediate coupling lever or against the end of the coupling pin.

Then check to make sure the rangefinder levers move freely as you focus the lens. Also make sure that the rangefinder optics are clean. Remember that the rangefinder uses front-silvered mirrors—be careful to avoid scratching the silvered surfaces. It's generally best to restrict your cleaning to blowing off dust with a hand blower.

Age or humidity may also damage the silver coatings of the mirrors and beamsplitters. In that case, replace the damaged component or the complete rangefinder assembly.

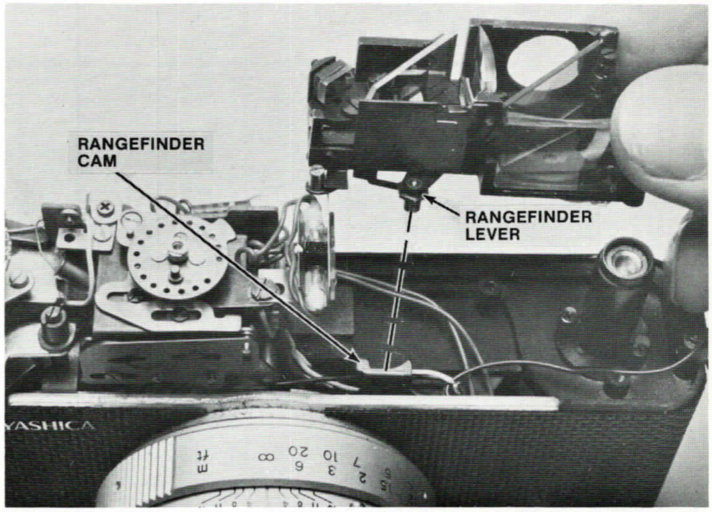


FIGURE 25 YASHICA ELECTRO-35

ADJUSTING THE RANGEFINDER

Most rangefinders have at least three adjustments:

1. **infinity**
2. **linearity** (distances closer than infinity)
3. **vertical shift** (horizontal alignment).

With most repairs, you'll have to make the infinity and vertical-shift adjustments. However, you should normally avoid disturbing the linearity adjustment.

The infinity adjustment controls the accuracy of the rangefinder. To check the adjustment, first select an infinity target. Your target should be at a distance that's at least 600 times the focal length of the lens.

A straight, vertical line—such as formed by a distant telephone pole—makes a good target. Look through the rangefinder and slowly rotate the focusing ring toward infinity. As the focusing ring comes against the infinity stop, the rangefinder images should superimpose.

You may find that the secondary image doesn't quite reach the primary image. Or the secondary image may move slightly past the primary image. In either case, you'll have to make the infinity adjustment.

The infinity adjustment changes the angle of the 45° mirror or the position of the movable component. In a movable-mirror system, look for an adjustment on the mirror itself. You may find an eccentric that shifts the mirror angle.

Or the adjustment may be on the linkage. With the Konica rangefinder, Fig. 26, a screw on the mirror lever rides against the linkage to the focus mount. By turning the screw, you can change the position of the mirror lever—and thereby the angle of the mirror. A clearance hole through the back of the rangefinder provides access to the adjustment screw.

If the rangefinder uses a movable lens, the infinity adjustment may be on the lever that carries the movable element. An eccentric may allow you to shift the movable lens to change its position, Fig. 27.

Remember that the infinity adjustment corrects the accuracy of the rangefinder—it somehow changes the angle of the 45° reflecting surface or the position of the movable component. By contrast, the vertical-shift adjustment has no effect on the accuracy; it's the same regardless of the subject distance. The vertical-shift adjustment simply shifts the secondary image up or down, Fig. 28.

You can check the vertical shift at any subject distance. Select a horizontal target such as the edge of a table. Then, as you rotate the focusing ring to move the secondary image, check to see if the images align vertically. If the vertical-shift adjustment isn't right, the secondary image will appear higher or lower than the primary image.

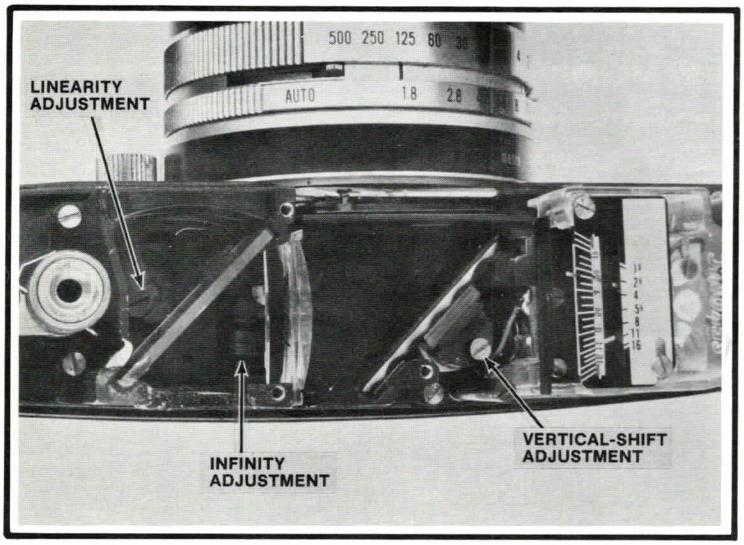


FIGURE 26

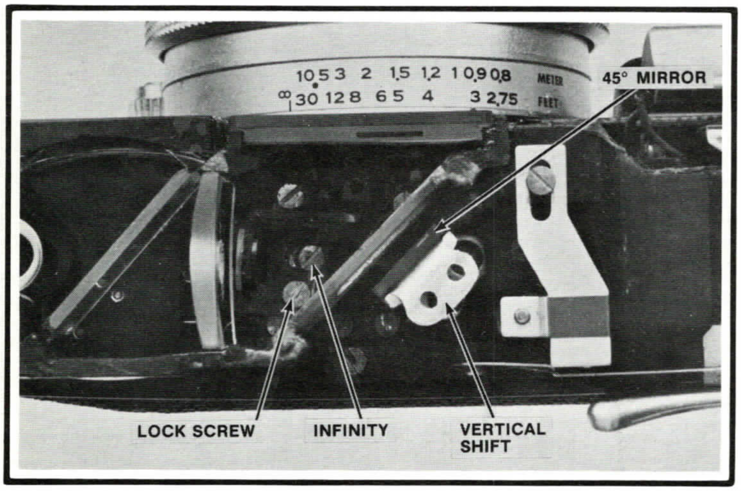


FIGURE 27 PETRI RACER

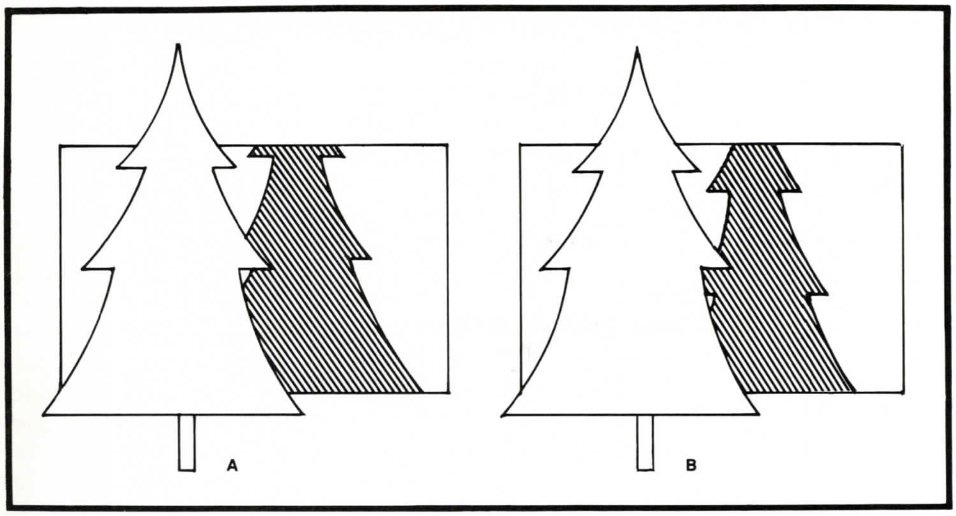


FIGURE 28 **Results of vertical shift. The secondary image is too high in A, too low in B.**

In most rangefinders, the vertical-shift adjustment is on the 45° mirror—either a movable mirror or a stationary mirror. The adjustment tilts the top of the mirror to shift the secondary image up or down. In Fig. 29, a setscrew comes against the back of the mirror bracket. Turning in the setscrew tilts the upper end of the mirror forward; the secondary image then moves up. Turning out the setscrew allows the upper end of the mirror to tilt back, moving down the secondary image.

Quite often the mount for the 45° mirror has a gap, Fig. 30. A conical wedge screw controls the gap. Turning down the wedge screw spreads the gap, moving up the secondary image. Turning out the wedge screw allows the sections of the mirror mount to move together and decrease the gap. Now the 45° mirror tilts toward the back of the camera, shifting down the secondary image.

It's possible, then, to have both adjustments on the 45° mirror. The vertical-shift adjustment tilts the mirror, and the infinity adjustment changes the angle of the mirror.

In most rangefinders, making the adjustment for infinity won't disturb the vertical-shift adjustment—and vice versa. Consequently, it may not matter which adjustment you make first.

1st ADJ.

But there are exceptions. With the rangefinder shown in Fig. 27, making the vertical-shift adjustment requires bending the mirror bracket. Notice the two holes in the top of the bracket. By inserting your tweezers into the holes, you can bend the bracket to tilt the mirror.

As you're bending the bracket, though, you may slightly change the angle of the mirror with respect to the base line. And that affects the adjustment for infinity. So, as a general rule, make the vertical-shift adjustment first. Then adjust the rangefinder for infinity.

The linearity adjustment, like the infinity adjustment, changes the position of the movable component. You'll normally find the linearity adjustment on the linkage. The adjustment changes the angle or length of the linkage to correct for finite distances.

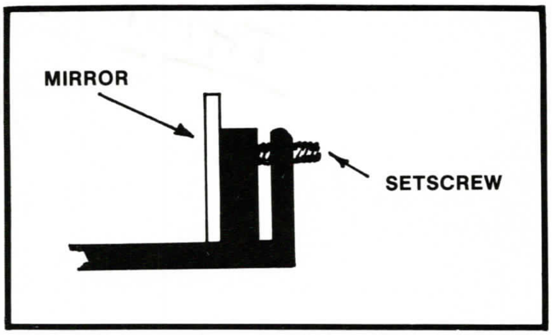


FIGURE 29

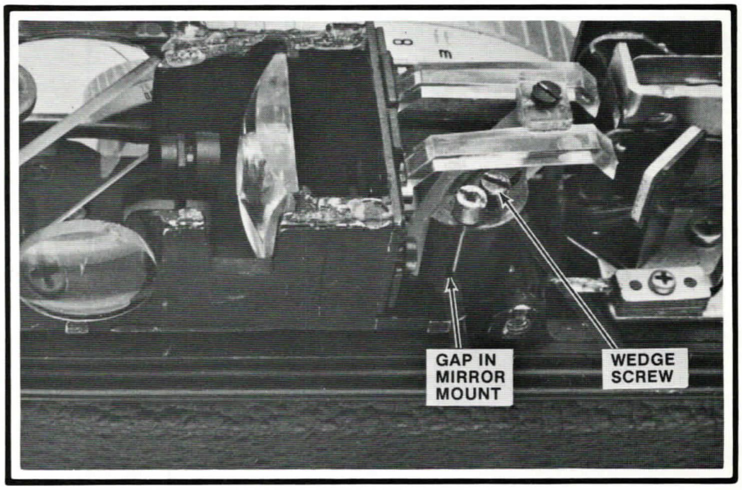


FIGURE 30 **MINOLTA HI-MATIC E**

TYP. ADJ 1 METER

It's typical for the manufacturer to specify a distance for making the linearity adjustment—normally one meter. After you adjust the rangefinder for infinity, you can check the alignment with a target placed one meter from the film plane. Set the lens to the 1m position—the images should superimpose.

If you adjust the linkage for one meter, recheck the rangefinder at infinity. Readjust the rangefinder for infinity and then recheck the alignment at one meter. Working back and forth between the two adjustments, you can correct the accuracy at all distances.

Adjusting the linearity can be a very time-consuming procedure. That's why you should normally avoid disturbing the linearity adjustment. But, to avoid disturbing the adjustment, you must be able to distinguish it from the infinity adjustment. For example, the manufacturer may provide two adjustments on the linkage to the movable component—one for infinity and one for linearity. How do you know which adjustment to use for infinity?

WATCH FOR THIS ADJ

Normally, the infinity adjustment is closer to the movable component. The linearity adjustment is a linkage adjustment—it somehow changes the position of the rangefinder lever with respect to the rangefinder cam.

Some rangefinders use an eccentric pin riding against the rangefinder cam as the linearity adjustment. Another design uses a two-piece lever. The linearity adjustment then changes the relationship of the two sections. Or there may be two rangefinder levers. An eccentric on one lever may then move the second lever.

But there's a more obvious clue you can use to pinpoint the infinity adjustment very quickly—**the adjustment for infinity is the one you can reach more easily**. Many cameras allow you to reach both the infinity adjustment and the vertical-shift adjustment without even taking off the top cover.

Clearance holes in the top cover often provide access to the two normal adjustments—the adjustments the manufacturer expects you to make. Typically, you can reach one clearance hole by sliding off the plate at the top of the accessory shoe.

For example, consider again the Konica rangefinder shown in Fig. 26. When you slide off the plate at the top of the accessory shoe, you can reach the vertical-shift adjustment through a clearance hole. A screw in the corner of the eyelens frame plugs the clearance hole for the infinity adjustment.

But reaching the linearity adjustment usually requires that you take off the top cover and perhaps the dust cover at the top of the rangefinder. With the Konica rangefinder, a hole in the dust cover provides access to the vertical-shift adjustment, Fig. 31. And, as you've seen, you can reach the infinity adjustment from the back of the camera. However, you must remove the dust cover to reach the linearity adjustment on the linkage, Fig. 26.

So, if reaching the adjustment requires disassembly, use caution—the adjustment may be intended as a factory-calibration point. And if the manufacturer provides easy access to the adjustment? You can then consider the adjustment to be safe; it's one the manufacturer intends for you to use in calibration.

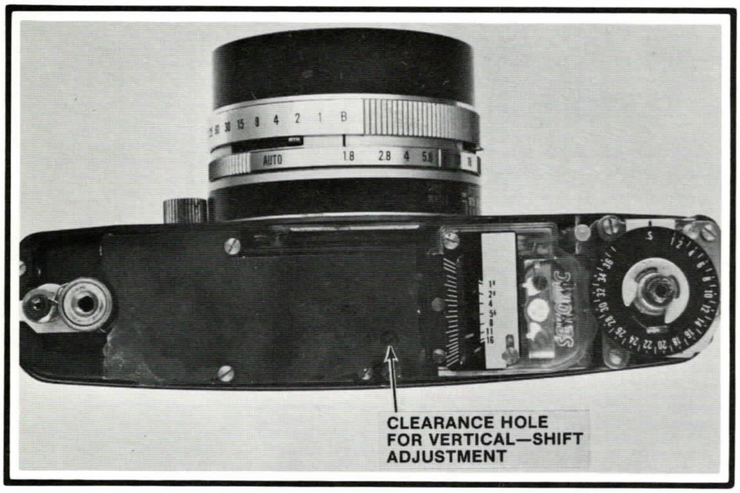


FIGURE 31

Many rangefinders have additional adjustments which you should also avoid disturbing. There's frequently an adjustment on the movable frame-line mask, Fig. 24. To adjust the frame-line mask, you must make a comparison—a comparison between the area enclosed by the frame lines and the area covered at the focal plane.

Consider that you're adjusting the frame-line mask. You have a target mounted one meter from the camera's film plane. Focus the rangefinder on the target and note the area enclosed by the frame lines. Then mount a ground glass in the camera's focal-plane aperture. Hold open the shutter on bulb and again note the area covered. Make the adjustment on the frame-line mask so that the frame lines enclose the same area.

After you calibrate the rangefinder, lock the adjustments. You can lock a setscrew adjustment by placing a dab of lacquer or matte-black paint on the threads. Lock an eccentric adjustment by placing a dab of lacquer on the sides of the eccentric. The lacquer prevents the adjustment from changing in normal use.

REPRESENTATIVE RANGEFINDER ADJUSTMENTS

Let's now look at the adjustments in some popular 35mm cameras. You can relate the adjustment procedures to most of the rangefinders you'll encounter.

Yashica Electro-35 and Minister-D

The Yashica infinity adjustment shifts the position of the movable lens, Fig. 32. In Fig. 32, we've removed the cemented dust cover from the top of the rangefinder. But you don't have to remove the dust cover to reach the infinity adjustment; a clearance cutout in the dust cover provides access.

In fact, you don't even have to remove the camera's top cover. To reach the infinity adjustment, slide off the cover plate at the top of the accessory shoe. A clearance cutout at the back of the top cover provides access to the vertical-shift adjustment, Fig. 32. The vertical-shift adjustment tilts the 45° mirror. In the Minister-D, remove the cover plug at the back of the top cover to reach the vertical-shift setscrew; in the Electro-35, remove the battery-test plate.

For the one-meter adjustment, Yashica provides an eccentric pin on the cam follower—the pin that rides against the rangefinder cam, Fig. 33. You should not have to disturb the one-meter adjustment.

Also avoid disturbing the 45° eccentric, Fig. 32. The 45° eccentric shifts the position of the entire rangefinder assembly. Use the 45° eccentric only if you can't bring in the infinity adjustment with the movable-lens eccentric.

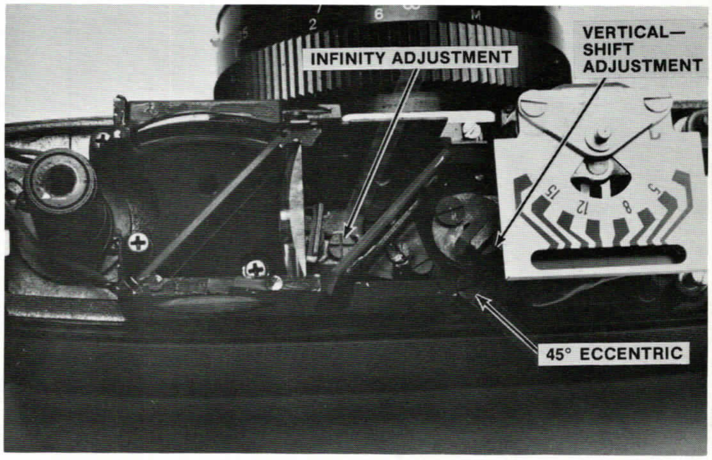


FIGURE 32 YASHICA MINISTER-D

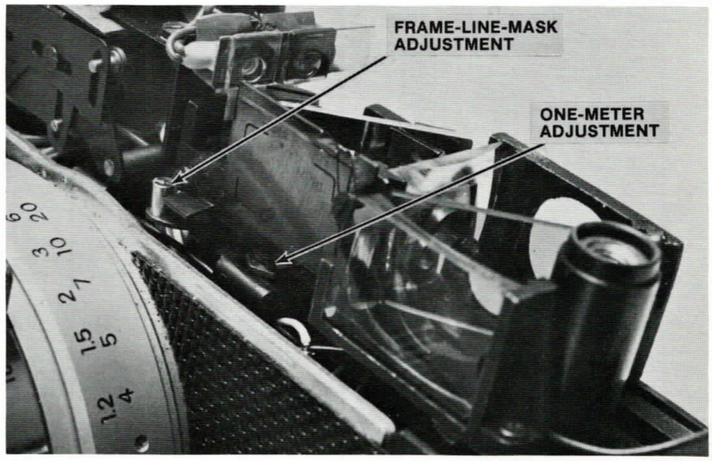


FIGURE 33 YASHICA ELECTRO-35

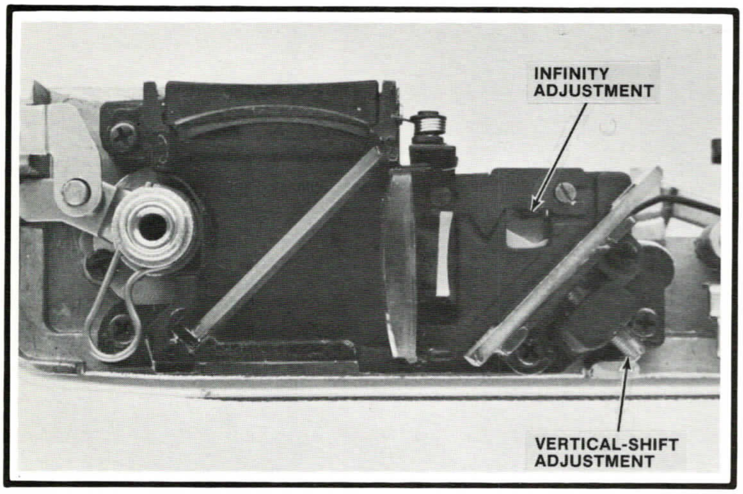


FIGURE 34 CANONET QL

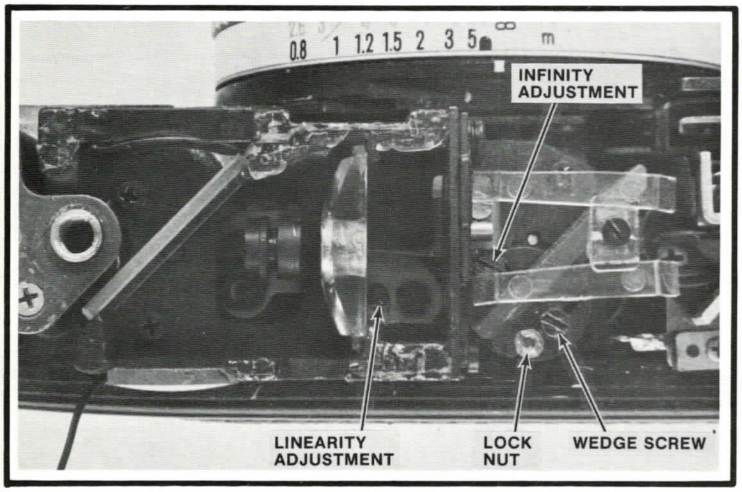


FIGURE 35 MINOLTA HI-MATIC E

Canonet QL

Canon uses the movable-lens rangefinder, Fig. 34. The infinity adjustment is on the lever linkage; you can reach the eccentric through the clearance hole, Fig. 34. Turning the eccentric changes the position of the movable lens. The vertical-shift adjustment. Fig. 34, tilts the 45° mirror.

As with many systems, you can reach both adjustments with the top cover in place. Slide off the accessory-shoe cover to reach the clearance hole for the infinity adjustment. Unscrew the plug screw at the back of the top cover to reach the setscrew for the vertical-shift adjustment.

Minolta Hi-Matic

Both adjustments in the Hi-Matic series of cameras are on the 45° mirror. The infinity adjustment shifts the mirror angle; the vertical-shift adjustment tilts the mirror. You can reach both adjustments after removing the accessory shoe.

To make the vertical-shift adjustment in the Hi-Matic E, first loosen the brass lock nut, Fig, 35. Then turn the wedge screw. Turning in the wedge screw spreads the gap on the mirror mount. The upper end of the mirror then tilts forward, and the secondary image moves up. Turning out the wedge screw allows the sections of the mirror mount to move together.

The linearity adjustment in the Hi-Matic E is on the rangefinder lever, Fig. 35. Normally, you should not have to disturb the linearity adjustment. However, if you do have to make the adjustment, Minolta recommends a target distance of 2 meters with most models.

In the Hi-Matic F, Fig. 36, all of the adjustments are on the 45° mirror. Here, you don't have to loosen a lock nut to make the vertical-shift adjustment; just turn the screw to tilt the mirror, Fig 37.

Notice in Fig. 36 that the Hi-Matic E uses a coupling pin between the cam and the rangefinder lever. As stressed earlier, be careful to avoid losing the coupling pin when you remove the rangefinder assembly.

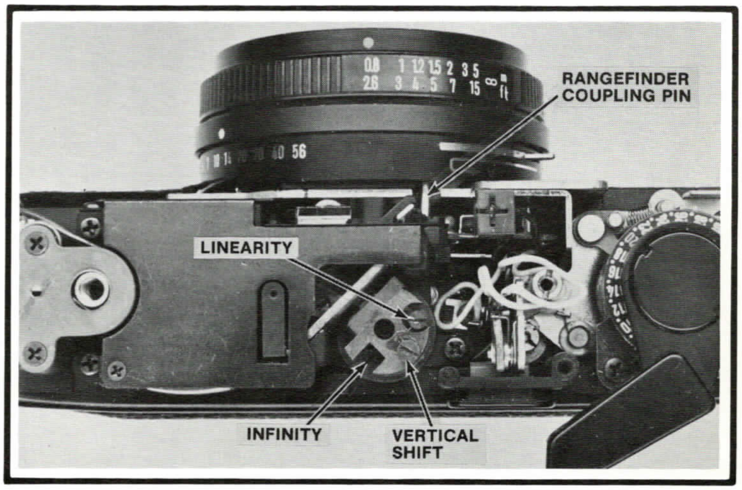


FIGURE 36 MINOLTA HI-MATIC F

Kodak Retina

The adjustments you've seen apply to most of the modern cameras. However, in older camera designs, you'll encounter a greater variety in rangefinder systems. Kodak Retina cameras use a rangefinder design that breaks many of the rules we've established. For one thing, the primary image—not the secondary image—moves as you focus the lens.

Fig. 38 shows the rangefinder in the Retina III. The movable component is the negative viewfinder lens. When you change the focus setting, the secondary image appears to move—just as in other rangefinder designs. But the secondary image actually remains fixed as the primary image moves.

Most of the Retina rangefinder adjustments, though, are similar to those you've studied. Adjust the rangefinder for infinity by turning the eccentric near the viewfinder lens, Fig. 38.

The linearity adjustment is at the end of the viewfinder-lens lever, Fig. 38. Kodak recommends making the linearity adjustment at a distance of 3.5 feet. If you disturb the linearity adjustment, recheck the accuracy at infinity.

To adjust the vertical alignment, tilt the upper end of the beamsplitter. First loosen the screw holding the beamsplitter bracket, Fig. 38. Sliding the bracket tilts the beamsplitter to raise or lower the secondary image. If you can't adjust the vertical alignment with the beamsplitter, you can move the primary image up or down. Loosen the two screws, one on either side of the viewfinder lens. Then shift the viewfinder lens up or down to raise or lower the primary image.

The adjustment at the top of the rangefinder controls the sharpness of the secondary image. After loosening the screw, Fig. 38, you can slide the secondary-image lens cell. Position the lens cell so that the secondary image appears as bright and sharp as possible.

Olympus XA

The Olympus XA, XA1, and XA2 are 35mm super-compact cameras. Only the top-of-the-line model, the XA, has a built-in rangefinder. Since the rangefinder has to fit in such a small space, its design is slightly different from those you've studied. And the adjustments aren't immediately obvious.

A lever under the rangefinder assembly couples the movable lens to a coupling pin. If you remove the rangefinder assembly, you can see the adjustment for infinity — a setscrew on the coupling lever. However, the rangefinder must be installed to make the adjustment.

Fortunately, Olympus provides an access for the adjustment—a clearance hole just above the focal-plane aperture. First remove the round disc that's cemented over the hole. You can then turn the setscrew adjustment for infinity without even removing the top cover.

The vertical-shift adjustment is on the movable lens, Fig. 39. Adjust the vertical alignment from the top of the rangefinder by rotating the knurled collar. The adjustment shifts the optical axis of the movable lens to raise or lower the secondary image.

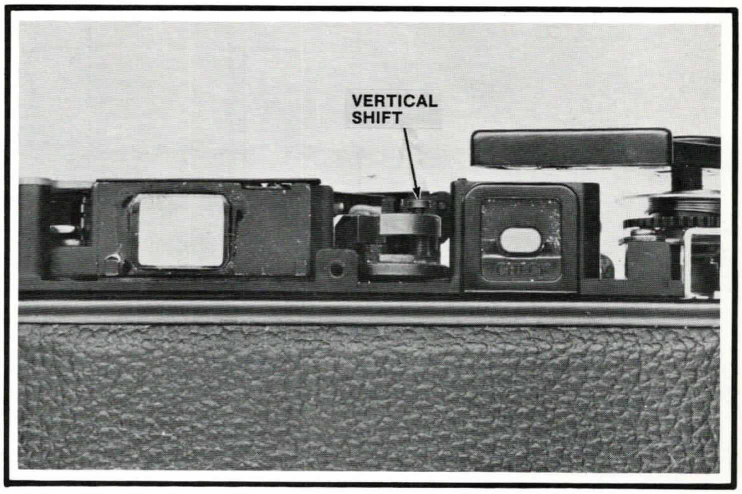


FIGURE 37 MINOLTA HI-MATIC F

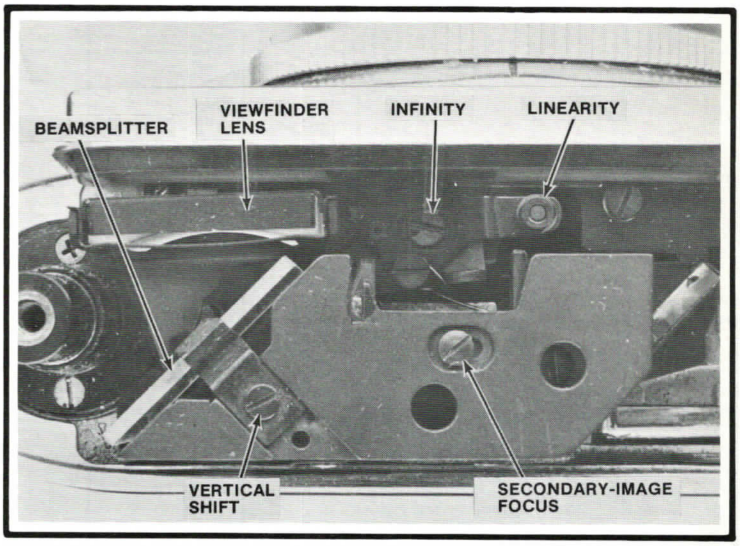


FIGURE 38 RETINA III

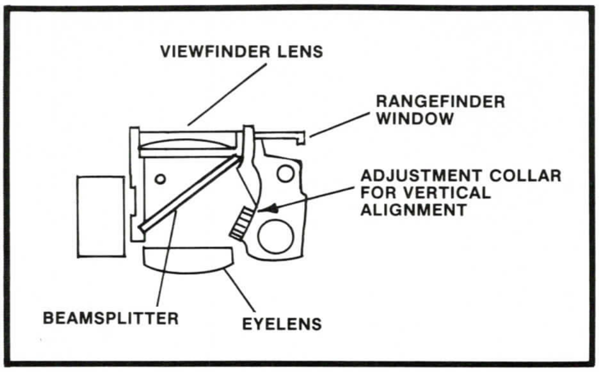


FIGURE 39 TOP VIEW OF OLYMPUS XA RANGEFINDER

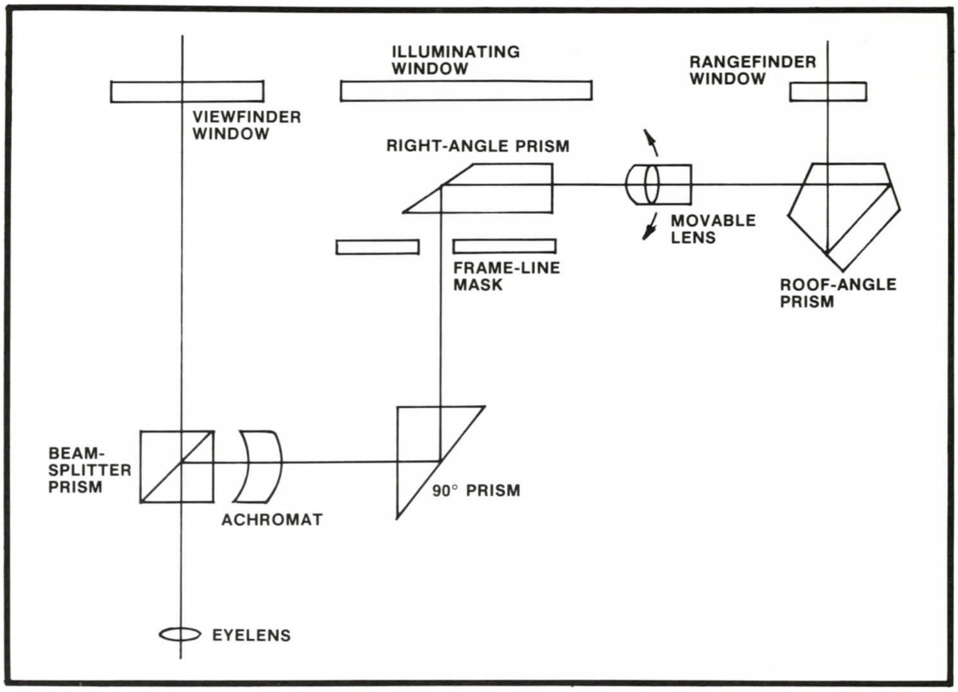


FIGURE 40 LEICA RANGEFINDER

THE LEICA RANGEFINDER

Leica rangefinders provide some exceptions to the general rules we've discussed. Early Leica screw-mount rangefinders use the moving-prism system shown in Fig. 12. Make the infinity adjustment by turning the setscrew on the prism arm; you can reach the setscrew after removing a plug screw at the front of the top cover.

The infinity adjustment changes the angle of the movable prism—nothing unusual here. But the vertical-shift adjustment is unique to Leica and Leica copies. A wedge prism sits in front of the movable prism. To align the images vertically, first remove the cover ring at the front of the rangefinder window. Then rotate the wedge prism.

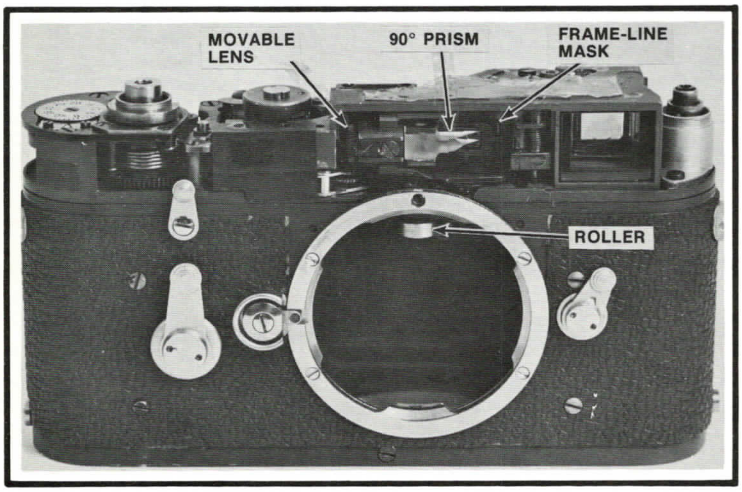


FIGURE 41 LEICA M3

In the M-series Leicas, the adjustments are more unique. The M-series Leica has perhaps the most sophisticated of current rangefinders. Fig. 40 shows the optical diagram.

The actual base length measured between the viewfinder window and the rangefinder window is 7cm. But, as you can see in Fig. 40, the optical path increases the effective base length. The rangefinder uses a movable lens to shift the secondary image horizontally.

A roller on the rangefinder lever, Fig. 41, rides against the back of the helicoid. As you turn the focusing ring, the rangefinder lever positions the movable lens, Fig. 41. The movable lens now shifts the path of the secondary image entering the right-angle prism, Fig. 40 and Fig. 41.

The right-angle prism reflects the secondary image through a rectangular cutout in the center of the frame-line mask. As you focus the lens, the frame-line mask moves to provide parallax compensation. But the frame-line mask has an additional refinement—it also changes position according to the focal length of the lens you've installed.

When you install the lens, a lug on the lens mount comes against the frame-selector bar, Fig. 42. The frame-selector bar positions a spring-loaded pin at the bottom of the rangefinder assembly, Fig. 43. Moving the spring-loaded pin shifts the frame-line mask to one of three positions. The frame-line mask now shows the field of view for the 35mm, 50mm, or 90mm lens.

Other than adjustments, there aren't many repairs you can make on the Leica rangefinder. A damaged component requires replacing the entire rangefinder assembly, Fig. 43. Since the rangefinder is expensive, Leica has supplied replacements on an exchange basis—send Leica the damaged rangefinder and receive in exchange a rebuilt rangefinder.

You can reach both the infinity adjustment and the linearity adjustment after removing the lens. Both adjustments are on the rangefinder lever, Fig. 44. Leica uses three distances to set up the rangefinder—infinity, ten meters, and one meter. For the infinity and ten-meter adjustments, use the screwdriver-slotted eccentric in the center of the roller, Fig. 44. Turning the eccentric shifts the position of the roller.

Suppose that the secondary image doesn't reach the primary image at infinity. You can then use the eccentric to shift the roller closer to the lens helicoid. Now the lens pushes in the rangefinder lever a greater distance at the infinity setting.

The one-meter adjustment is at the opposite end of the rangefinder lever, Fig. 44. Here, an eccentric bushing provides the pivot point. By first loosening the screw that holds the rangefinder lever, you can rotate the eccentric.

Complete calibration requires that you work back and forth between the infinity and one-meter adjustments. If you're installing a new or rebuilt rangefinder, you should check the alignment at all three target distances—infinity, ten meters, and one meter. However, if you're adjusting the original rangefinder, you may only have to make the infinity adjustment. Avoid disturbing the one-meter eccentric.

There's just one problem—you must remove the rangefinder lever to take out the rangefinder assembly. And removing the rangefinder lever disturbs the one-meter adjustment. The screw holding the rangefinder lever also locks the one-meter eccentric.

However, you can scribe the adjusted position. Before you remove the rangefinder lever, scribe the one-meter eccentric and the rangefinder lever to note the adjusted position. On reassembly, rotate the one-meter eccentric until your scribe marks align. Then tighten the screw holding the rangefinder lever.

The vertical-shift adjustment positions the movable lens, Fig. 44. However, the eccentric pin doesn't change the angle of the movable lens; it just shifts the movable lens up or down. To reach the vertical-shift adjustment, remove the plug screw at the front of the top cover.

Also notice the overtravel adjustment, Fig. 44. With the lens removed, the stop lever, Fig. 44, comes against the overtravel eccentric. Installing the lens causes the stop lever to move away from the overtravel eccentric as the rangefinder lever moves toward the back of the camera.

At infinity, the lens pushes in the rangefinder lever as far as it can. Here, the rangefinder lever should not come against the

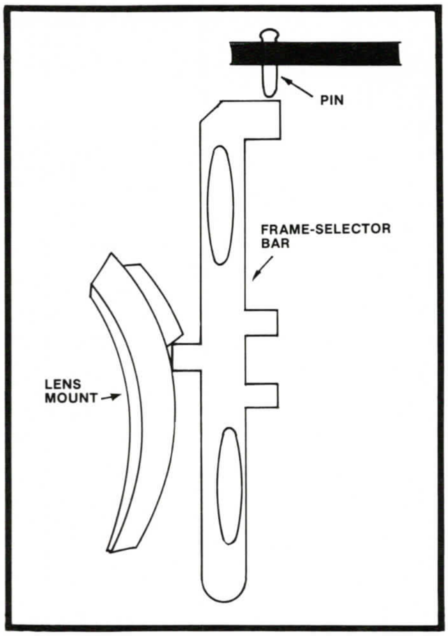


FIGURE 42

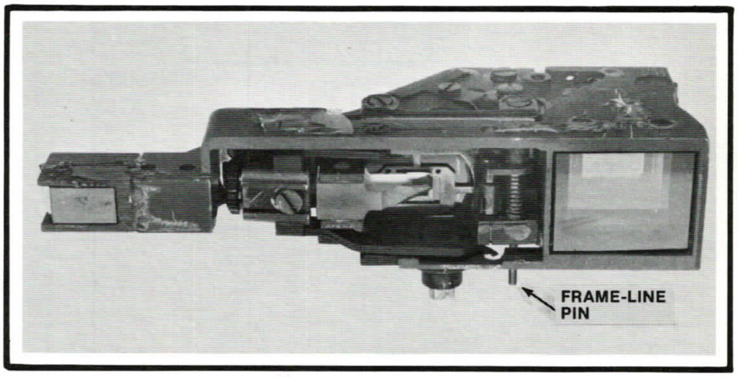


FIGURE 43

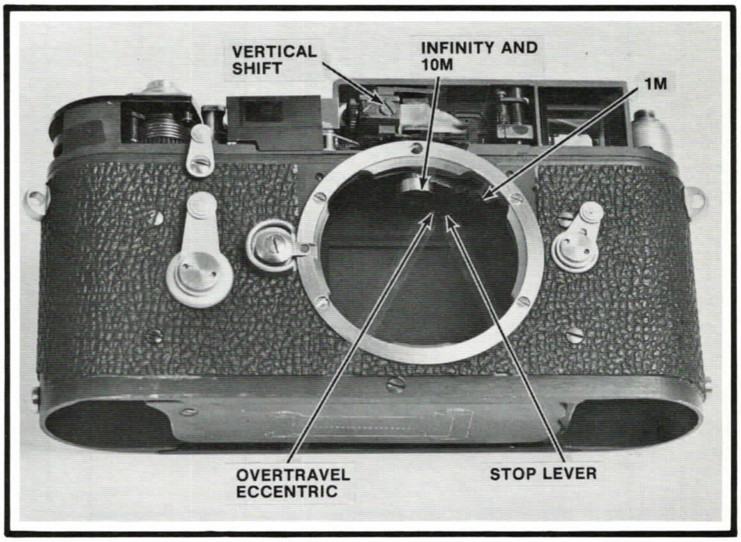


FIGURE 44

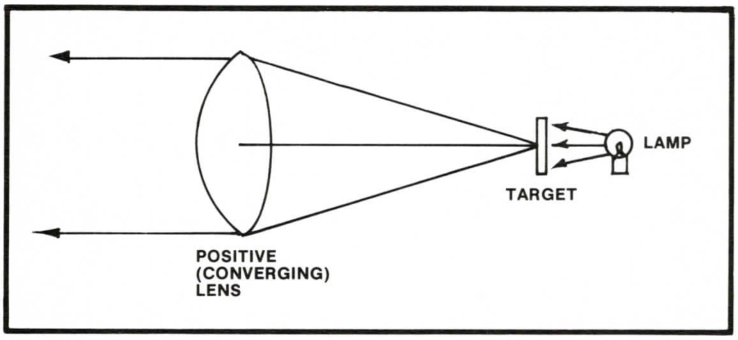


FIGURE 45

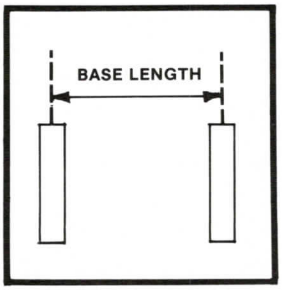


FIGURE 46

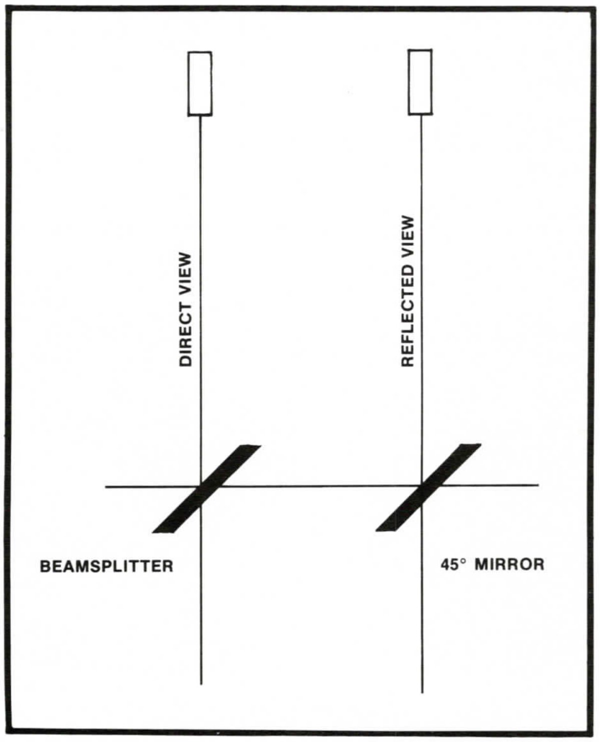


FIGURE 47

overtravel eccentric. Why? The overtravel eccentric may then block the rangefinder lever before the images superimpose at infinity.

You must also remove the overtravel eccentric to take out the rangefinder assembly. But you won't disturb the adjustment. Since the overtravel eccentric fits tightly over the screw, it remains in its adjusted position.

To remove the rangefinder, first scribe the one-meter eccentric. Then remove the rangefinder lever, the one-meter eccentric, and the stop lever by taking out the screw. Next remove the screw and eccentric bushing for the overtravel adjustment; the overtravel eccentric comes out with the screw.

Two screws still hold the rangefinder assembly. You can reach the screws from inside the supply-spool chamber. Using a long screwdriver, reach through the body shell and take out the two screws. Then lift out the complete rangefinder assembly, Fig. 43.

RANGEFINDER TEST TARGETS

When discussing rangefinder adjustments, we mentioned using an infinity target. But that's not always so easy. Perhaps you aren't located close to a window that offers a clear view of a subject at infinity.

You may then wish to make an infinity target that can be used anywhere. Fig. 45 shows one type. The target, perhaps a resolution-test chart printed on a film base, sits at the focal point of a positive lens. A lamp behind the target provides illumination.

When you look through the front of the positive lens, the target appears to be an infinite distance away. Why? Because the target is at the focal point of the positive lens. Light from the lamp passes through the target and leaves the lens in parallel rays, Fig. 45.

There's one problem in building such a test target—that's in acquiring a large positive lens. The lens must be large enough in diameter to span both windows of the camera (the viewfinder window and the rangefinder window). But the focal length isn't critical—so long as you can locate the target at the focal point. Suppliers of surplus optical equipment sometimes have suitable lenses at reasonable prices.

Camera manufacturers often use a different type of target—a **bar target**, Fig. 46. Here, the separation between the bars equals the base length of the rangefinder. Each rangefinder window then aligns with one bar, Fig. 47.

When you view the bar target through the finder, you see four bars—two primary-image bars and two secondary-image bars. At infinity, one primary-image bar and one secondary-image bar should overlap. So, with a properly adjusted rangefinder at infinity, the bar target should appear as shown in Fig. 48A.

What if the rangefinder isn't properly adjusted at infinity? If the secondary image moves past the primary image, the center bar appears as shown in Fig. 48B. And if the secondary image fails to reach the primary image, the center bar appears as shown in Fig. 48C. You can then make the infinity adjustment until the center bars precisely overlap.

Unfortunately, different rangefinders have different base lengths. So, if you draw a bar target for one rangefinder, it

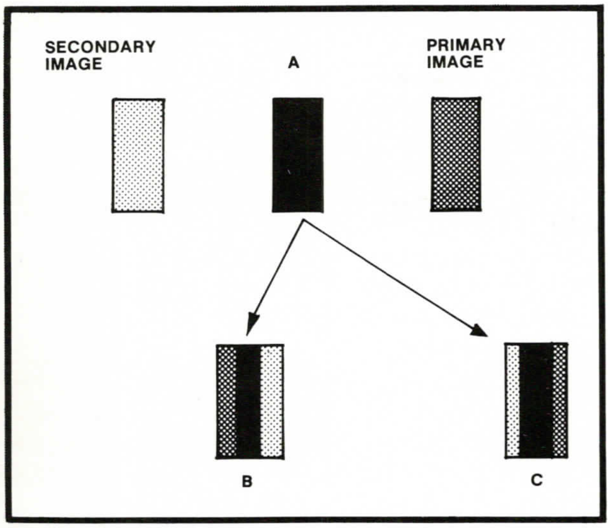


FIGURE 48

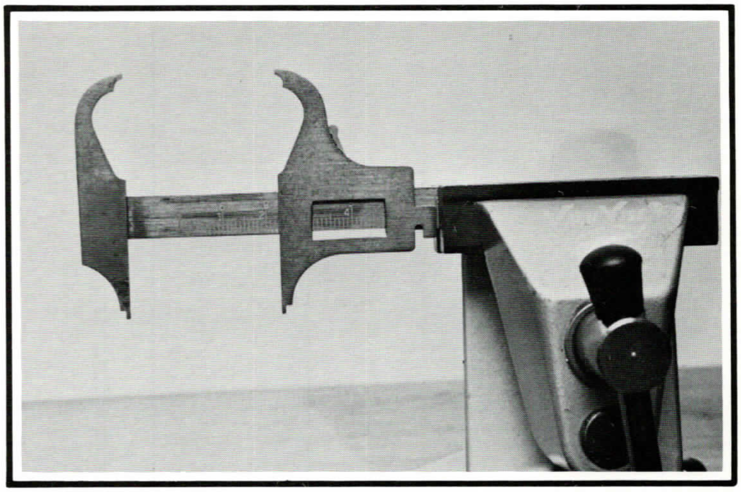


FIGURE 49

won't work for another rangefinder—unless the two rangefinders have identical base lengths.

An alternate technique involves using an adjustable bar target—one in which you can change the separation between the bars. For example, you might use a vernier caliper. Just set the vernier caliper so that the distance between the jaws equals the base length of the rangefinder.

Mount the vernier caliper in a vise, Fig. 49. And mount the camera on a tripod so that the rangefinder windows are the same height as the vernier. The distance between the vernier and the camera isn't important. However, it's critical that the rangefinder base is parallel to the vernier caliper.

Now look at the vernier through the viewfinder. You should see both the primary image and the secondary image of the vernier caliper. As you turn the focusing ring toward infinity, the secondary image moves toward the primary image. And, at the infinity setting, the images should appear as shown in Fig. 50. Notice that one jaw of the secondary image just touches the corresponding jaw of the primary image.

You can use a similar technique to determine the base length. Suppose that you have a properly adjusted rangefinder—one that you've set with an infinity target. You can then use the rangefinder to set the vernier. Change the vernier setting until the viewed images appear as shown in Fig. 50. The reading on the vernier now corresponds to the base length of the rangefinder.

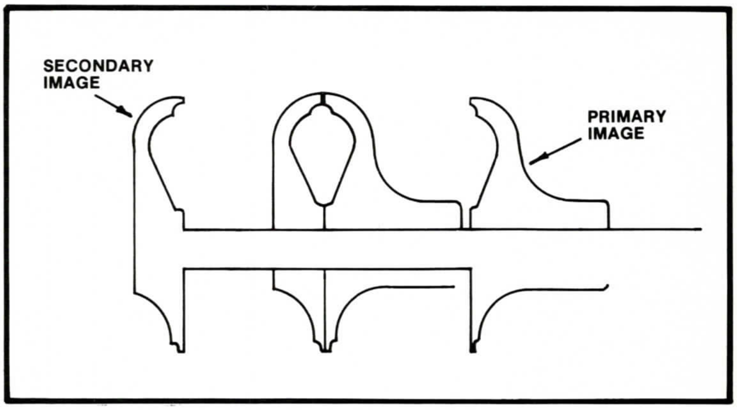


FIGURE 50

TEST-YOURSELF QUIZ #3

1. You can consider a target to be at infinity if it's at a distance that's at least 600 times the focal length of the lens.
2. Your target for infinity is 30 meters from the camera. Is this distance sufficient for a 50mm lens? YES For a 35mm lens? YES For a 135mm lens? NO
3. A rangefinder adjustment that changes the angle of the 45° mirror with respect to the base line is an adjustment for
   A. rangefinder accuracy
   B. vertical alignment
4. With a certain movable-lens rangefinder, you can see two adjustments on the rangefinder lever. You can reach one of the adjustments through a hole in the rangefinder dust cover. But you must remove the dust cover to reach the other adjustment. The adjustment you can reach through the clearance hole provides your adjustment for
   A. vertical alignment
   B. infinity
   C. linearity
5. In a movable-lens rangefinder, the vertical-shift adjustment is normally on
   A. the movable lens
   B. the beamsplitter
   C. the 45° mirror
6. In the screw-mount Leica rangefinder, a 90° prism replaces the
   A. movable lens
   B. rotating wedge
   C. movable mirror
7. The screw-mount Leica has a wedge prism in front of the 90° prism. The wedge prism provides
   A. correction for subjects within infinity
   B. your adjustment for infinity
   C. your adjustment for one meter
   D. your adjustment for vertical shift

D PG 18

8. The one-meter rangefinder adjustment in the M-series Leica is on
   A. the rangefinder lever
   B. the prism lever
   C. the wedge prism
9. The M-series Leica uses a
   A. movable-mirror rangefinder
   B. movable-prism rangefinder
   C. movable-lens rangefinder
   D. rotating-wedge rangefinder

PG 18 C

10. You can use a vernier caliper as a target for infinity if you set the vernier to a distance that equals the BASE LENGTH of the rangefinder. For the adjustment at infinity, what should be the distance between the rangefinder and the vernier? -0- NO DIFF.

PRINCIPLES OF AUTOFOCUS

Autofocus systems automatically set the lens position according to the subject distance. Most autofocus (AF) systems use the same basic principles as those you've just studied—they determine the subject distance by calculating the unknown side of a triangle.

Some autofocus systems then use a tiny motor—a servo motor—to rotate the focus ring of the lens. But in most autofocus cameras, a spring rotates the focus ring.

Cocking the shutter moves the focus ring in the direction that tensions the spring. The focus ring now moves the lens away from the film—slightly beyond the closest-focus distance. When you push the release button, the spring starts pulling the focus ring in the opposite direction. And the lens moves toward the infinite-distance setting.

For a subject at infinity, the lens moves in all the way—as close to the film as the mechanical system permits. At closer subject distances, the autofocus system stops the lens during its travel. The closer the subject, the sooner the autofocus system stops the lens.

Fig. 51 shows a typical system. A coil spring pulls the focus ring in a clockwise direction. As the focus ring rotates clockwise, it draws the lens toward the film.

To stop the lens, the AF circuit supplies an electrical signal—a signal that causes the electromagnet, Fig. 52, to release a pawl. The pawl engages the ratchet-shaped teeth at the edge of the focus ring. Stopping the rotation of the focus ring simultaneously stops the movement of the lens.

Each ratchet-shaped tooth then relates to a subject distance—a series of focus steps rather than a continuous focus. The lens must reach its stop position before the shutter can release. Consequently, there's a slight delay between the time you push the release button and the actual exposure. The delay may be around 1/10 second for a subject at infinity. Here, the lens must move its maximum distance.

The gears in Fig. 52 provide a mechancical retard—or governor—for the focus ring. As the focus ring rotates, the governor controls the speed. The AF circuit then gains the time it needs to select the proper focus. Without the governor, the focus ring would rotate so quickly that the pawl wouldn't be able to stop the movement. And the lens would always move to infinity.

When you cock the shutter for the next exposure, the cocking mechanism resets the lens. In Fig. 52, the cocking mechanism drives the focus ring in a counterclockwise direction. The focus ring now moves the lens toward the front of the camera.

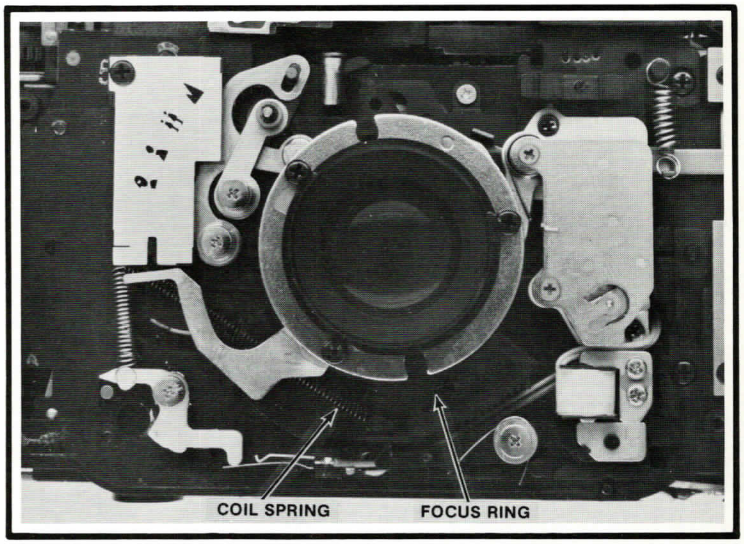


FIGURE 51 Yashica autofocus camera in the "ready" position—the shutter cocked and the lens at the maximum distance from the film.

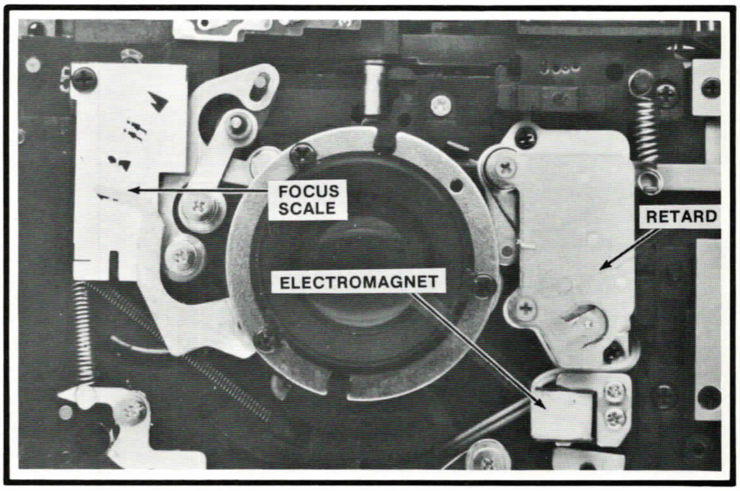


FIGURE 52 Here the electromagnet has stopped the focus ring at the closest-focus setting.

You can see that the systems for moving and stopping the lens are relatively simple. The sophistication is in the system that seeks the subject distance and signals the electromagnet. There are two basic types of systems:

1. **passive systems**
2. **active systems.**

A passive autofocus system relies on ambient light to determine the subject distance. Like the rangefinders you've studied, the passive system sees the light reflected from the subject. It then uses the angle of a mirror to detemine the subject distance.

But there's a drawback—the passive system won't work in low-light situations. An active autofocus system overcomes the drawback by supplying its own distance-seeking output. The output may be a beam of light that reflects from the subject and returns to the camera. Or the output may be a sound wave (sonar).

With your understanding of optical rangefinders, you have most of the background you need to study autofocus systems. However, autofocus systems also rely on sophisticated electronic-control circuits. So, in this assignment, we'll just discuss the optical and mechanical principles of passive and active autofocus systems. Later in your course, you'll gain the electronics background you need to repair autofocus cameras.

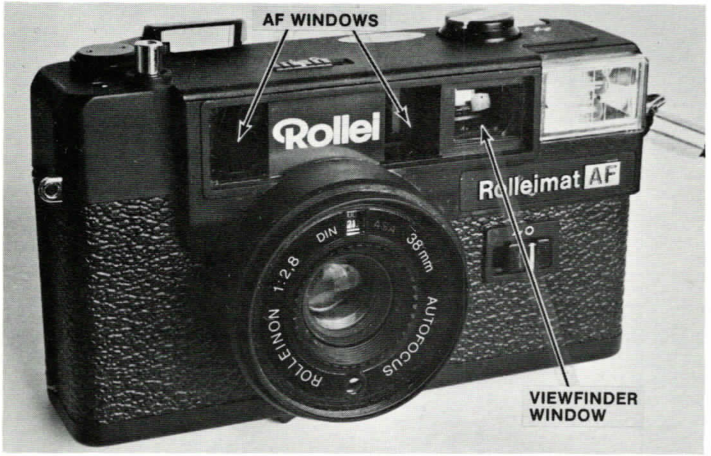


FIGURE 53

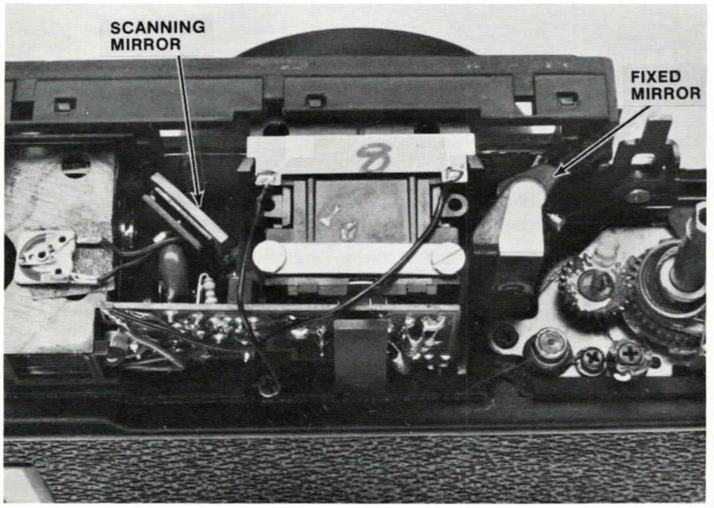


FIGURE 54 PASSIVE AF SYSTEM IN ROLLEIMAT AF

PASSIVE AUTOFOCUS SYSTEMS

Honeywell developed the first autofocus design to be used in 35mm cameras—the Visitronic system. But Honeywell never made an autofocus camera. Rather, the company sells the autofocus design to camera manufacturers. You'll therefore encounter different cameras using the same autofocus system.

Like an ordinary rangefinder, the Visitronic system has two separated views of the subject, Fig. 53. One window provides a direct view. AF frame lines in the center of the finder, similar to the rangefinder frame lines in Fig. 2, allow you to establish the direct view on the subject you want in focus. The autofocus system focuses on the portion of the subject you've located within the AF frame lines.

A fixed mirror sits behind the direct-view window, Fig. 54. A movable mirror—the **scanning mirror**—sits behind the other window. As the lens moves toward the film, the scanning mirror swings in a counterclockwise direction, Fig. 55.

The scanning mirror now sweeps from point A, Fig. 55, to point B—from the closest focusing distance to infinity. When the scanning mirror locates the subject, the autofocus system stops the inward travel of the lens.

Fig. 56 shows the complete system. As you advance the camera's wind lever, the lens moves away from the film—slightly beyond the closest focusing distance. The scanning mirror, mechanically coupled to the lens assembly, swings fully counterclockwise. Now the system is ready to begin the scan.

By centering the AF frame on the subject, you've determined the signal output of one of the two light sensors in Fig. 56. A prism reflects light from the fixed mirror to sensor B. The voltage output of sensor B provides the reference signal—a signal that tells the autofocus system where your subject is located.

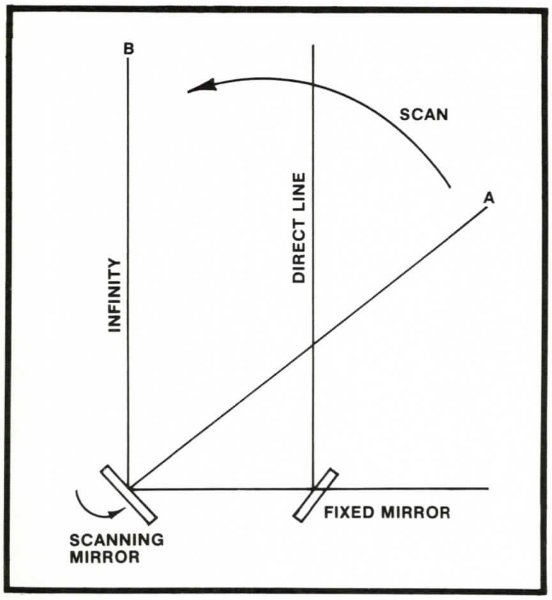


FIGURE 55

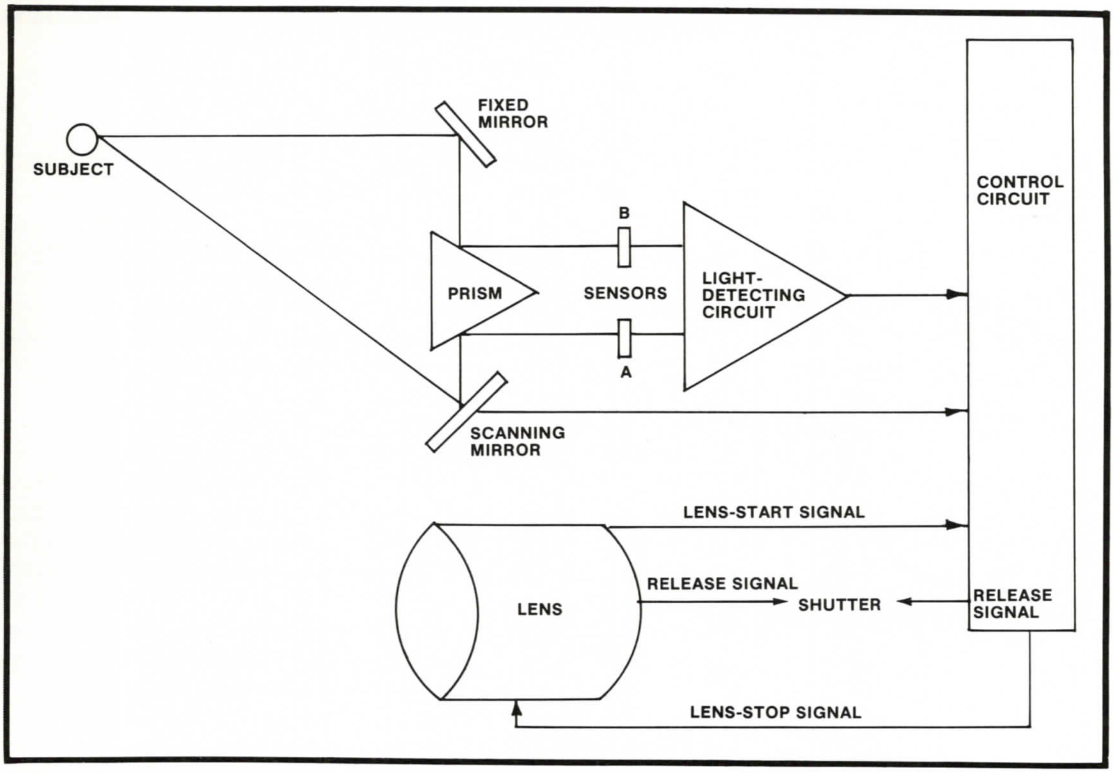


FIGURE 56

The closer the subject, the larger the voltage output of sensor B. Similarly, a highly reflective subject causes sensor B to put out a larger voltage. But the Visitronic system doesn't care about the actual voltage level. Rather, it simply compares the voltage of sensor B to the voltage output from sensor A.

Notice that sensor A sees the light reflected from the scanning mirror. The sensor-A voltage then changes as the scanning mirror sweeps across the field of view. A light-detecting circuit, Fig. 56, compares the sensor-A output to the sensor-B output. When the scanning mirror reaches the subject's position, the two outputs are the same.

Consider that you've just pushed the camera's release button. As the lens starts moving in, a switch closes to signal the control circuit—the signal tells the control circuit that the lens has started its movement. Now the light-detecting circuit compares the two sensor outputs.

Initially, the sensor-B output is higher than the sensor-A output. But as the scanning mirror gets closer to the subject, the sensor-A output increases. For a close subject, the scanning mirror may only have to sweep a short distance before the sensor-A output equals the sensor-B output. The more distant the subject, the further the scanning mirror has to sweep. And, as a result, the further the lens moves toward the film.

When the two sensor outputs are the same, the light-detecting circuit sends a signal to the control circuit—a signal that says the lens has reached the proper focus position. The control circuit then tells the electromagnet, Fig. 52, to stop the lens movement. Also, once the lens stops, the control circuit sends the release signal to the shutter.

What if the output of sensor A never reaches the output of sensor B? In that case, the control circuit never sends the stop signal to the electromagnet. And the lens moves in as far as it can—the infinity setting. When the lens reaches the infinity setting, it closes a switch that sends the release signal to the shutter.

You can now see what may result if there's a defect in the autofocus system. If the control circuit never sends the lens-stop signal to the electromagnet, the autofocus system always selects infinity—regardless of the subject distance. Or a defective autofocus system may shut off the electromagnet as soon as the lens starts to move. In that case, the lens always selects the closest focus setting.

SERVICE NOTES

Normally, however, you don't make repairs on the autofocus circuits. The Visitronic system is a complete module, Fig. 57. If there's a circuit malfunction, just replace the complete AF module.

AF is complete module.

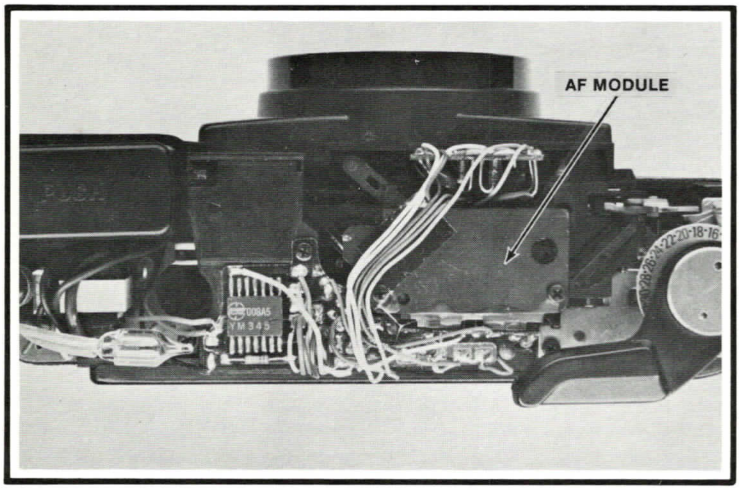


FIGURE 57 PASSIVE AUTOFOCUS SYSTEM IN YASHICA AF

ACTIVE AUTOFOCUS SYSTEMS

An active autofocus system sends out its own signal to seek the subject distance. Most active systems send out a beam of infrared light. The infrared light beam reflects from the subject and returns to the camera.

The infrared light comes from a special type of light-emitting diode, or LED. When current flows through the LED, the LED emits light—a solid-state light bulb. The LED in autofocus systems, though, emits infrared light. Some manufacturers then refer to the diode as the IRED—infrared-emitting diode.

In the Canon AF35M, Fig. 58, the IRED takes the place of the scanning mirror. The IRED sweeps across the field of view as the lens moves toward the film. As the IRED sweeps, it emits a beam of infrared light.

Fig. 59 shows how the system works. The AF35M has a built-in power winder. Besides advancing the film and cocking the shutter, the power winder drives the lens to the start position—slightly beyond the closest-focus setting. The IRED, mounted to a lever that couples to the lens mechanism, now points to position A in Fig. 59.

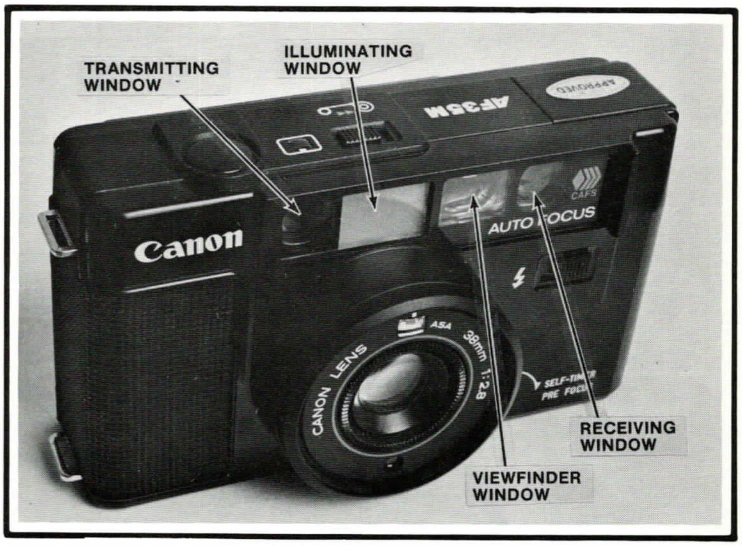


FIGURE 58

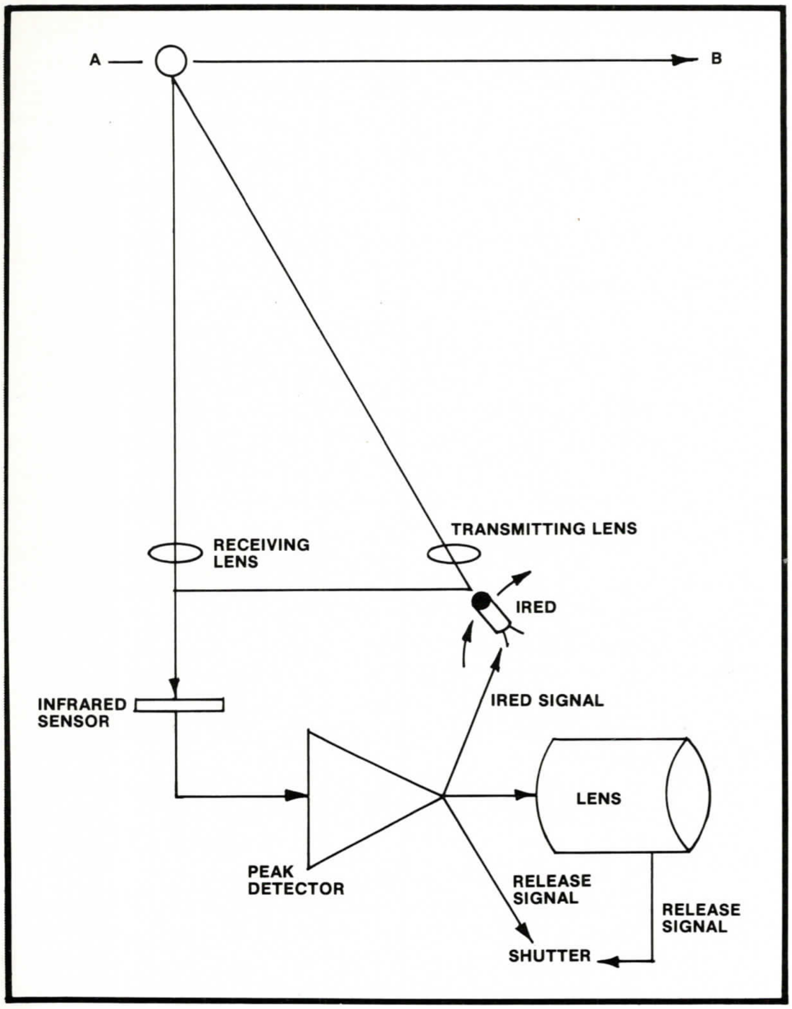


FIGURE 59

Pushing down the release button allows a spring to start pulling the lens toward the film. As the lens starts to move, the IRED turns on. The infrared light beam now sweeps across the field of view—from point A to point B, Fig. 59, as the lens moves toward the infinity setting.

Notice that the infrared light first passes through the transmitting lens, Fig. 59 and Fig. 58. The transmitting lens collimates the infrared light. As a result, the infrared light forms a small beam—a small circle of light that scans the subject distance. The small diameter of the light beam allows the autofocus system to be very selective.

As the IRED sweeps, reflected infrared light returns to the camera. The camera's receiving lens collects the reflected infrared light and routes it to the infrared sensor, Fig. 59. The infrared sensor is a special type of light sensor that responds to infrared light.

The voltage output of the infrared sensor increases as the amount of infrared light increases. When the IRED pinpoints the subject, the voltage output of the infrared sensor reaches its maximum level—its peak value.

A peak-detector circuit, Fig. 59, senses when the infrared sensor has reached its peak value. Now the peak-detector circuit sends the lens-stop signal to the electromagnet. And, once the lens stops, the circuit sends the release signal to the shutter.

If the subject's at infinity, the infrared sensor may not reach a high enough signal level to stop the lens. Then, as with the Visitronic system, the lens moves in fully—the infinity setting. Here, the lens closes a switch that sends the release signal to the shutter.

What malfunction would a defective IRED then cause? If the IRED fails to emit infrared light, the infrared sensor can't develop the voltage output that stops the lens. And the lens always moves to infinity.

With the AF35M, you can quickly check the IRED. Just look through the transmitting window, Fig. 58, and push the release button. You should see a red circle of light move across the window. When the lens reaches the stop position, the IRED should turn off. However, with most infrared systems, you can't actually see the light from the IRED. The light output from the IRED in other cameras is usually outside the visible spectrum.

The advantage of the infrared system is that it will work in low-light situations—even in complete darkness. But certain picture situations will fool even the IRED. For example, a matte-black subject absorbs all of the infrared light—nothing reflects to the camera. Or you may be shooting a shiny subject that reflects all of the infrared light at an angle that entirely misses the infrared detector. In either case, the lens selects the infinity setting.

A different error may occur if your subject includes a lot of infrared light—perhaps a sunset. The infrared detector may then see so much infrared that it immediately stops the lens. And you get the closest distance setting.

Consequently, any system that uses a sweeping component has a built-in problem—you don't know there's going to be a focus problem until you've taken the picture. Most sweeping-component systems include a focus indicator that moves along a scale as the lens moves toward infinity. After

you've shot the picture, you know what distance setting the autofocus has selected. But you don't know beforehand.

In the AF35M, the focus indicator appears in the finder, Fig. 60. As the lens moves in, the indicator moves along the scale. The indicator stops when the lens stops. If the indicator stops at the mountain symbol, you know the lens has selected the infinity setting. But what if your subject's at a close focusing distance? Something has apparently fooled the autofocus system, and your picture will be out of focus.

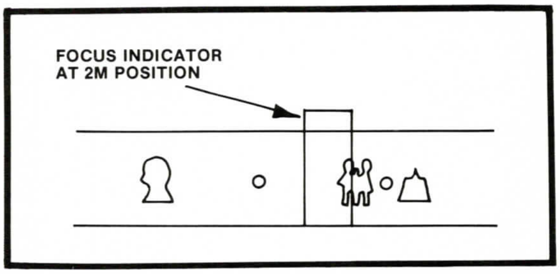


FIGURE 60

FIGURE 61

Later infrared systems correct the problem by using a nonsweeping IRED. In the Canon ML, Fig. 61, the IRED turns on when you depress the release button part way—not when the lens starts to move. The autofocus system now selects the focus setting. When you press the release button the rest of the way, the lens moves to the preselected distance.

The advantage of the system is that you know before you shoot the picture that the autofocus can handle the subject. If the autofocus can handle the picture situation, an indicator lights up in the finder. There are three indicators—a profile for close-ups, a group for middle distances, and a mountain for infinity. And if none of the indicators turns on? Then you know that the autofocus system can't handle the picture situation.

Minolta carries the error indication one step further in their autofocus cameras. If the autofocus can't focus on your subject, some models give you a beeping sound. Another model, the "Talker," literally tells you if there will be a focus error.

Fig. 62 shows the Minolta autofocus system. Here, the infrared LED remains fixed in position. When you push the camera's release button part way, the LED turns on. Infrared light then strikes the subject and returns to the infrared detector.

The autofocus system determines the subject distance by the angle of reflection. As you've already learned, the angle of reflection is smaller for a distant subject and larger for a closer subject, Fig. 62. The technique for measuring the angle uses a special detector—a detector with four separate "channels," Fig. 62.

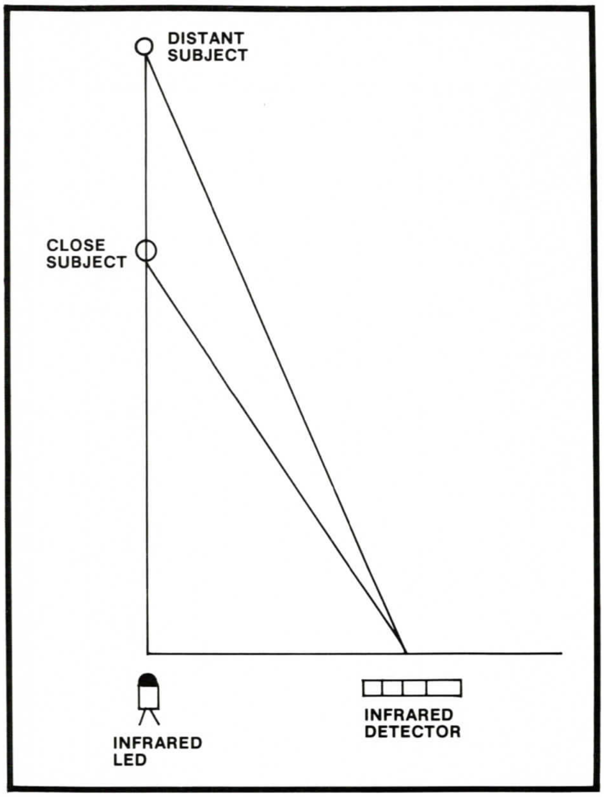


FIGURE 62

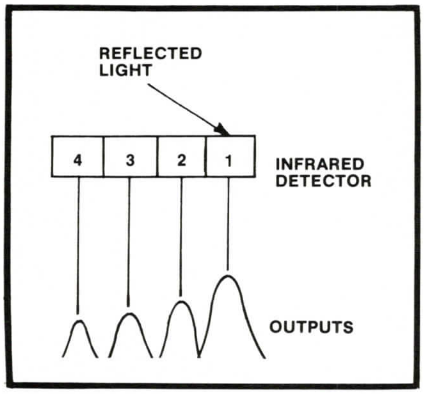


FIGURE 63

Each channel develops its own voltage output—an output in proportion to the amount of reflected light it sees. For a close subject, channel 1 receives the most light, Fig. 63. Fig. 63 shows how the voltage outputs of the four channels then appear.

A detection-level circuit now looks at the four voltages. The circuit determines which of the four voltages exceeds the detection level. In Fig. 64, only the output of channel 1 is sufficiently high. Thus the autofocus system knows that the subject is at the minimum focusing distance.

When you push the release button the rest of the way, the lens moves to its first position—the closest-distance position. The autofocus system therefore preselects the distance setting when you push the release button part way. To change the preselected distance, you must let up and redepress the release button.

Next consider that the subject is slightly further away. The angle of the reflected light decreases. More light now strikes channel 2. When the outputs of both channel 1 and channel 2 exceed the detection level, the autofocus system preselects the next distance setting—position 2.

As the angle decreases further, channel 1 receives less light and channel 2 receives more light. The autofocus system selects position 3 when only channel 2 exceeds the detection level. Position 4 occurs when both channel 2 and channel 3 exceed the detection level.

In all, the Minolta offers seven possible focus settings. The lens moves to the infinity setting—position 7—when only channel 4 exceeds the detection level.

So, in order for the lens to move to the proper position, at least one channel must exceed the detection level. But no more than two channels may exceed the detection level. What if none of the channels puts out a high enough voltage? Or if three channels simultaneously exceed the detection level? You then get the error signal.

The voltage output of any channel also changes according to the reflectance of the subject. A dark-colored subject may reflect very little infrared light. It may then seem that none of the channels would put out a high enough voltage. Or a light-colored subject may reflect so much of the infrared light that more than two channels might tend to exceed the detection level.

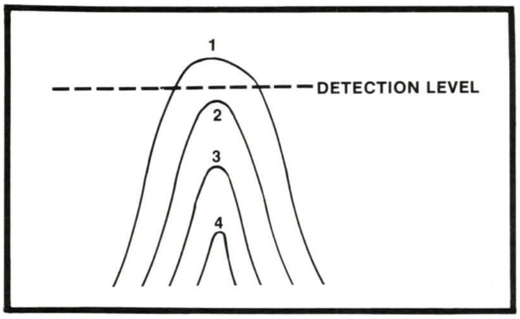


FIGURE 64

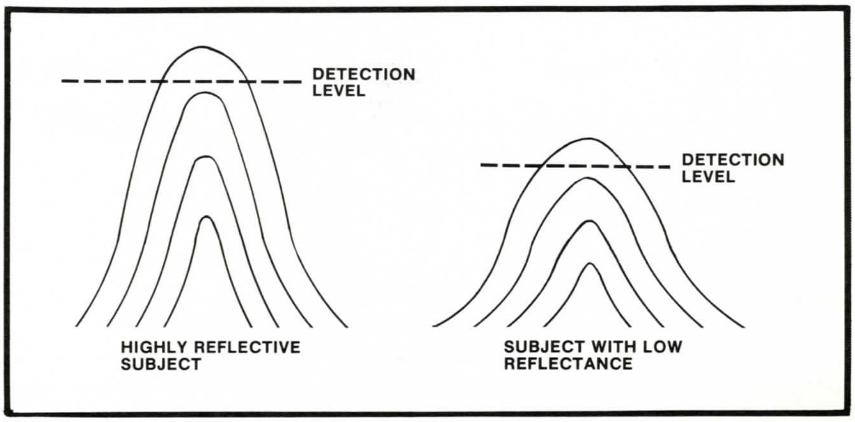


FIGURE 65

However, a special circuit compensates for the reflectance of the subject. The circuit actually raises or lowers the detection level. If the subject reflects a lot of light, the correction circuit raises the detection level; the circuit lowers the detection level if the subject reflects little light, Fig. 65.

Under certain circumstances, the correction circuit may not be able to raise the detection level enough; more than two channels then exceed the detection level. Or the correction circuit might not be able to lower the detection level enough. And none of the channels exceeds the detection level. Again, the autofocus system gives you the error indication.

It may sound like only an electronics engineer could service such a sophisticated system. But that's not the case. The Minolta autofocus system, like the Visitronic, is a complete module, Fig. 66. If there's a malfunction, you simply replace the complete unit—just remove two screws and unplug the autofocus module from the circuit board, Fig. 67. A replacement autofocus module comes preadjusted from the factory.

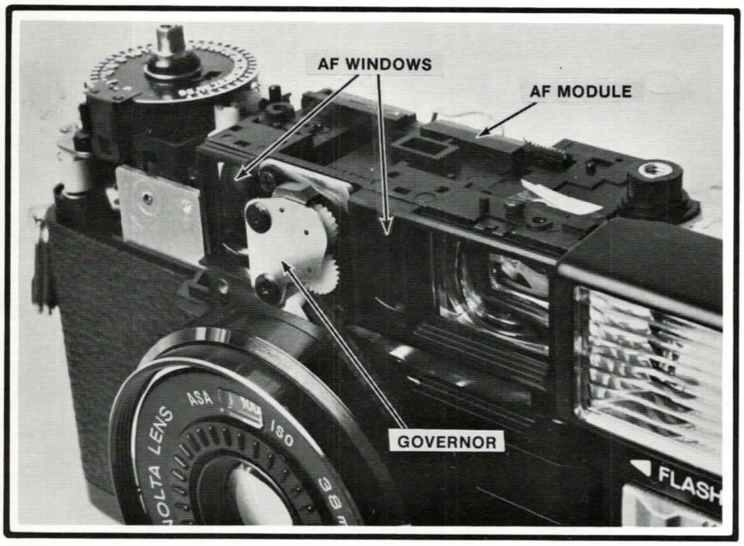


FIGURE 66 MINOLTA AF2

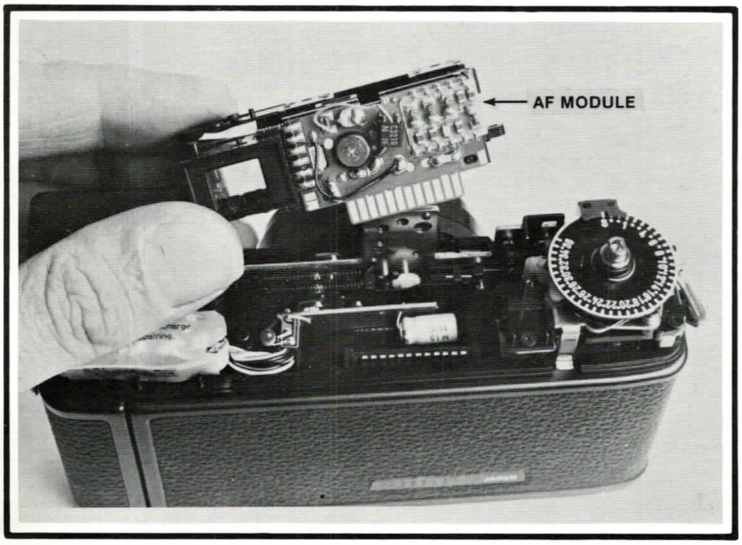


FIGURE 67 MINOLTA AF2

TEST-YOURSELF QUIZ #4

1. An autofocus system that uses an infrared LED is a/an ACTIVE (passive, active) system. An autofocus system that relies on ambient light to determine the subject distance is a/an PASSIVE (active, passive) system.
2. An autofocus system that uses a sweeping component seeks the subject distance
   A. as the lens moves toward infinity
   B. as the lens moves toward the closest-distance setting
   C. before the lens starts to move
3. An autofocus system that uses a nonsweeping component seeks the subject distance (select from the choices for question #2) C
4. To stop the lens movement, most autofocus systems use
   A. an electromagnet
   B. an intertia retard
   C. an infrared detector
5. When checking the autofocus in a camera using the Visitronic system, you cover the autofocus windows and release the shutter. The lens should move
   A. to the infinity position
   B. to the minimum-focus position
   C. to a random, intermediate position
6. As you cock the shutter in a camera using the Visitronic autofocus, the lens moves
   A. to the infinity position
   B. to the minimum-focus position
   C. slightly beyond the minimum-focus position
   D. slightly beyond the infinity position
7. You're using an infrared autofocus system to photograph a matte-black subject. If the subject is two meters from the camera, the lens will select
   A. the two-meter position
   B. the minimum-focus position
   C. the infinity position
   D. a random position
8. The advantage of an infrared system that uses a nonsweeping LED (as opposed to a sweeping LED) is that
   A. it can focus on matte-black subjects
   B. it provides an error indication

100

ADJUSTMENTS IN AUTOFOCUS CAMERAS

Most autofocus cameras have at least three adjustments:

1. **infinity focus**
2. **autofocus selectivity**
3. **autofocus accuracy at distances closer than infinity.**

The adjustment techniques, however, vary according to the individual system. Also, some systems require voltage and current adjustments as well as optical adjustments. For example, with the Canon AF35M, the adjustments include setting the peak-detector voltage and the current through the IRED.

In this assignment, we'll just discuss the general adjustments. You can then apply the information to the specific procedures for individual cameras. Later in your training program, you'll learn more about voltage and current measurements with electronic cameras.

Most repairs, however, may not require adjustments on the autofocus system. And, in some cases, the factory does not recommend adjustments—even though adjustment points are provided. With the Minolta AF2, Fig. 66, there are adjustments on the autofocus module. But the factory recommends replacing the complete module rather than adjusting it.

First check to see that the autofocus system is working properly. Try covering the autofocus windows as you release the shutter—with most systems, the lens should move in all the way (infinity). Then try focusing on subjects at different distances. Make sure the lens position does change as the target distance changes.

CHECK POINT

With some cameras, you know what focus setting the autofocus system has selected. A needle may move along a scale as the lens moves in, Fig. 52. Fig. 68 shows the scale in the Konica autofocus camera using the Visitronic system.

But with other cameras, there may be no indication as to the actual focus setting. How can you then check the accuracy of the autofocus system? You may have to hold open the shutter and check the focus at the film plane.

You'll also have to hold open the shutter to check the focus at infinity. When the lens moves in fully, it should produce a sharp image of a distant target. To check the adjustment, cover the autofocus windows as you release the shutter; the lens should move in fully. Or you can simply disengage the pawl that latches the focus ring.

Then, while holding open the shutter, check the focus at the film plane. The method for holding open the shutter depends on the particular camera. Most autofocus cameras don't have bulb settings. You must therefore use a "trick" to hold open the shutter.

In the Canon AF35M, for example, you can mechanically open the shutter. With the shutter cocked, just disengage the latch that holds the opening blade. Reach the latch through a clearance hole in the front plate—the white plastic pin shown in Fig. 69. The shutter now opens.

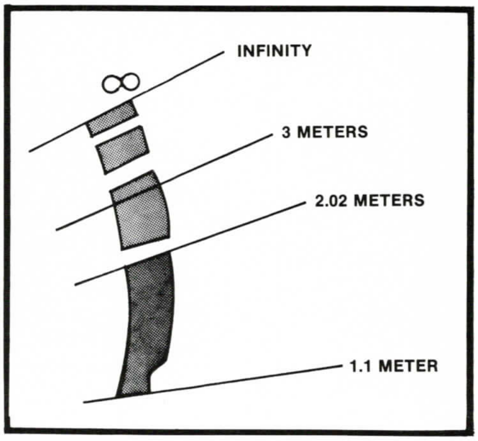


FIGURE 68 FOCUS SCALE IN KONICA C35

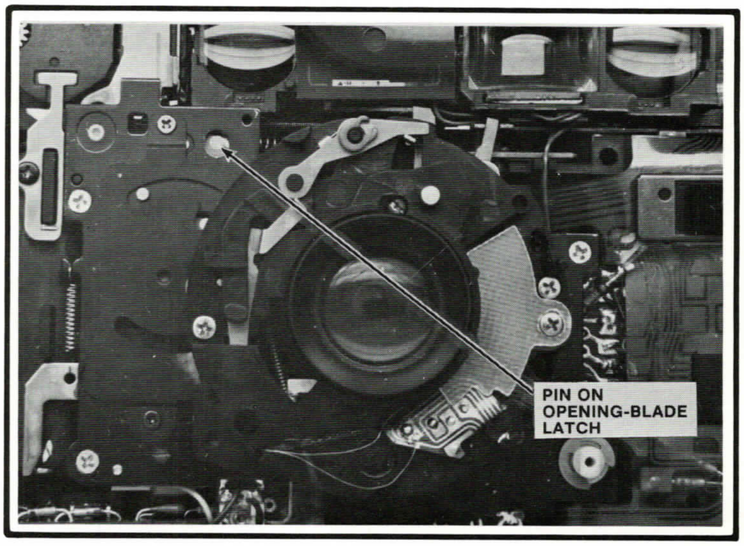


FIGURE 69

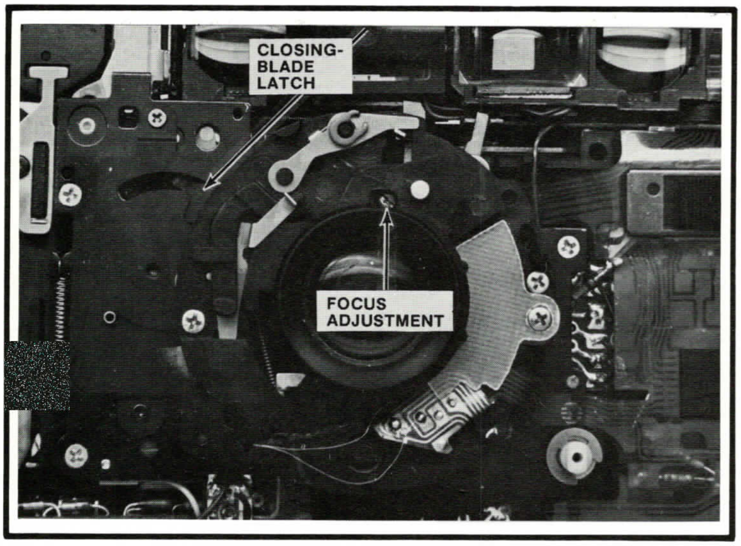


FIGURE 70

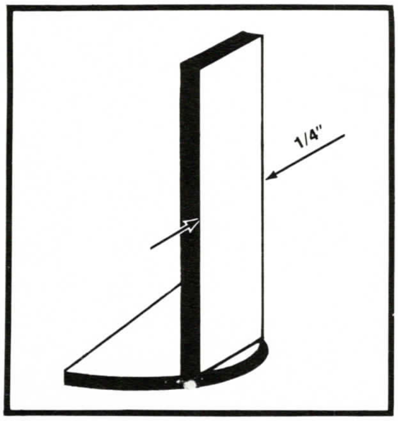


FIGURE 71

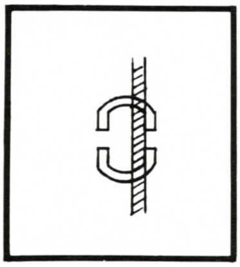


FIGURE 72

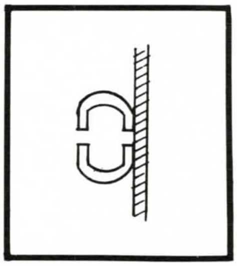


FIGURE 73

A second latch holds the closing blade. To close the shutter, disengage the closing-blade latch—the latch visible through a slot, Fig. 70.

The adjustment for infinity requires changing the position of the lens with respect to the focus ring. In the Canon AF35M, the eccentric pin, Fig. 70, provides the focus adjustment. Canon specifies a distance of 8m (rather than infinity) when the lens moves in fully. Just turn the eccentric until the lens produces a sharp image of the 8m target.

Other autofocus cameras provide similar adjustments. Quite often, you need only loosen the screws at the front of the lens, Fig. 52. You can then turn the lens group to set the focus at infinity. Remember, the focus ring must already be at the setting for infinity—it moves to infinity when you release the shutter with the AF windows covered.

The adjustment for infinity has no effect on the accuracy or selectivity of the autofocus system. Depending on the system, you may not want to disturb the factory-set autofocus adjustments. But you should still check the system to make sure the autofocus is both accurate and selective.

Checking the autofocus system requires a test target—a target that you can place at known distances from the camera. For the selectivity test, you want to make sure the autofocus system pinpoints a subject located within the AF frame.

Fig. 71 shows one type of target that's suitable for a selectivity test. The target bar should be around ¼" wide. You can make such a target from a piece of cardboard. Although the color of the target isn't critical, the surface should not be highly reflective. Nor should it be matte-black. As you've seen, highly reflective and matte-black subjects can fool infrared systems.

Provide some separation between the target and the wall. You can then determine whether the autofocus system focuses on the wall or on the target. The distance between the target and the camera should approximately equal the minimum-focus distance of the lens.

For example, suppose that you're checking the Minolta AF2. The minimum-focus distance is 0.9m. And the next focus position is 1.27m. So, to check the selectivity, position the camera around one meter from the target. The target should be at least 0.27m from the wall.

Now the camera should select one of two focus positions—either for the target or for the wall. Align the camera so that the target appears within the AF frame as shown in Fig. 72. When you release the shutter, the lens should move to the closest-focus position.

If the lens moves past the closest-focus position, the autofocus system is focusing on the wall rather than on the target. You then know that the system isn't sufficiently selective. Also try moving the AF frame just off the bar target, Fig. 73. Now the lens should focus on the wall.

There's another type of target you can use for infrared systems. Simply cement a white bar or circle in the center of a matte-black target, Fig. 74. When you position the AF frame on the white circle, the lens should stop at the target distance. But with the AF frame slightly off the white circle, the lens should move to infinity. Why? Because the matte-black surface won't reflect the infrared light.

The target shown in Fig. 74 is ideal for checking the Canon AF35M. At a distance of 2m, the diameter of the infrared light beam should be approximately 40mm. A 40mm circle cemented on a matte-black surface then makes a good test system for selectivity.

Position the camera 2m from the target. And center the white circle in the AF frame. When you release the shutter, the lens should move to the 2m position, Fig. 60. Then repeat the test with the AF frame just off the white circle. This time, the lens should move to the infinity position.

Whenever you're checking selectivity or accuracy, the camera's top cover should be in place. The top-cover windows limit the angle of light acceptance. Making the test without the top cover could result in an error—the autofocus system sees too wide an angle.

The adjustment for selectivity depends on the particular system. Minolta provides an adjustment on the frame-line mask. After loosening the screw accessible through a clearance hole, Fig. 75, you can shift the mask horizontally. The AF frame then moves to correspond with the IRED's line of sight.

The Canon AF35M doesn't have an adjustment on the frame-line mask. If the system isn't sufficiently selective, the diameter of the infrared light bundle is too large. The transmitting lens isn't collimating the infrared light into a tight bundle.

To adjust the selectivity, it's necessary to collimate the infrared light. You can collimate the light by moving the IRED closer to or further from the transmitting lens, Fig. 76. Canon uses shims behind the IRED to control the distance.

Fortunately, it's rarely necessary to adjust the selectivity. But you should check the selectivity if the customer complains of out-of-focus pictures. If you find an error, the adjustment can be slow and painstaking. That's why many technicians prefer to replace the complete AF module. The cost of a replacement module may be offset by the time required to make the selectivity adjustment.

For the accuracy test, you can use just about any type of target. Some manufacturers recommend a target with a light-gray color—ideally, an 18% neutral gray. Just check the focus at different camera-to-target distances. And assure that the lens moves to the proper focus position.

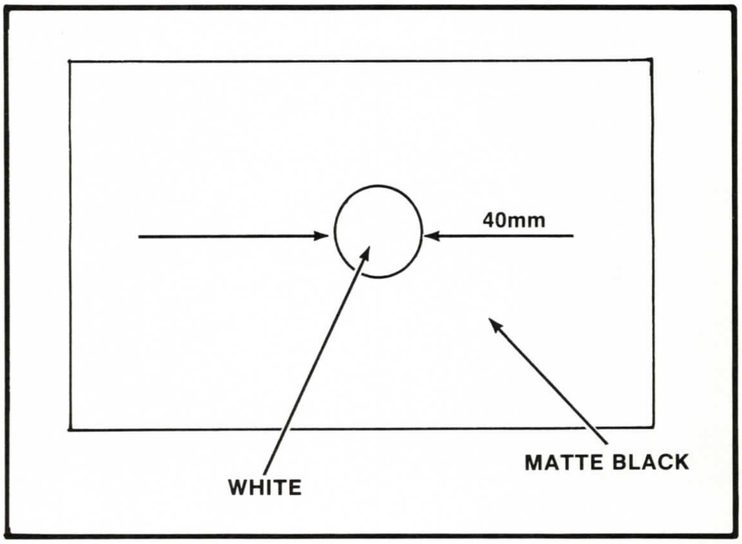


FIGURE 74

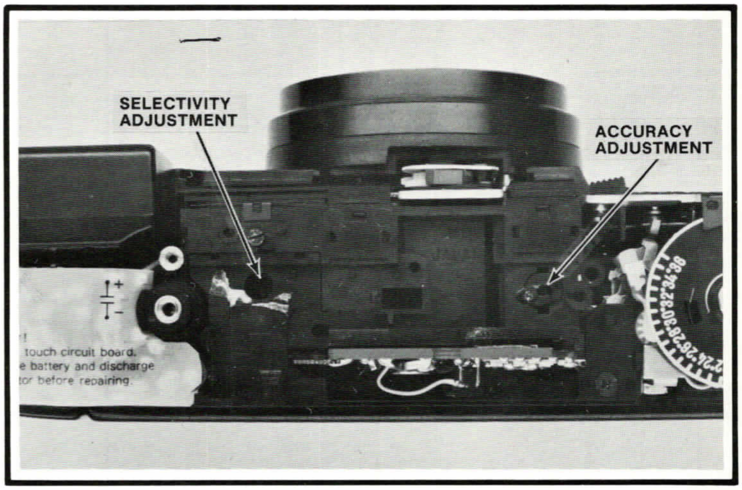


FIGURE 75 MINOLTA AF2

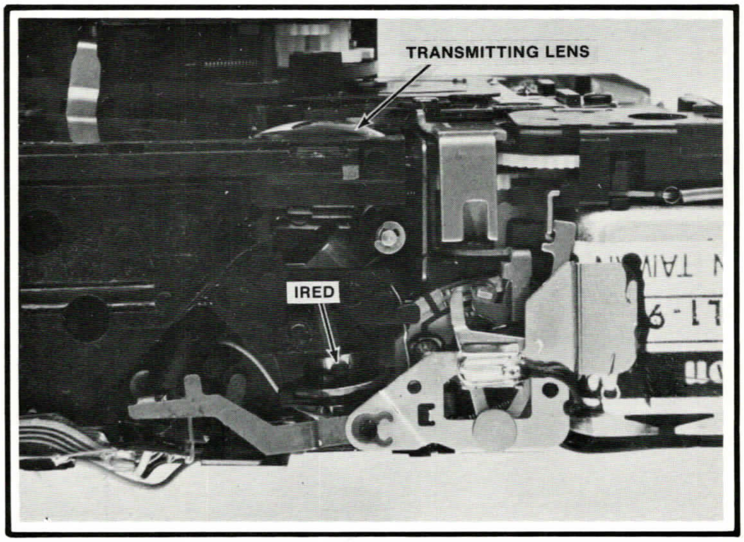


FIGURE 76

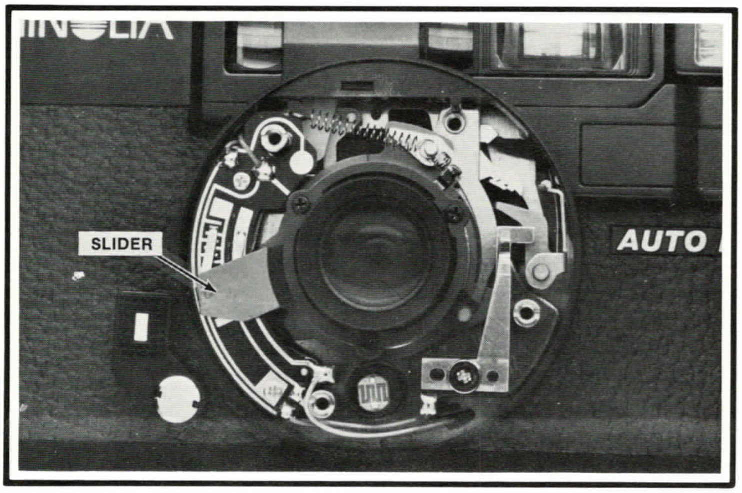


FIGURE 77 SLIDER AT POSITION 1

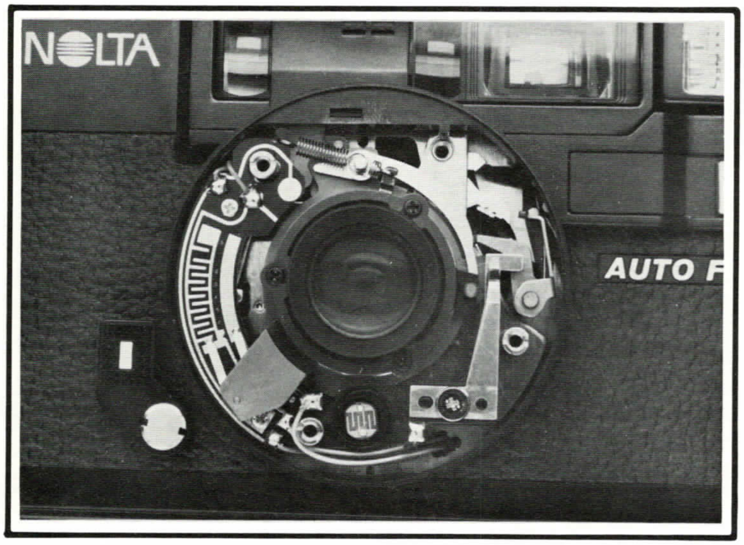


FIGURE 78 SLIDER AT POSITION 7

There's only one problem—depending on the camera, you may or may not have an indication as to the lens position. As you've seen, systems using a sweeping component (mirror or IRED) frequently include a distance scale. You then know the actual distance setting after the exposure, Fig. 68.

But a nonsweeping system normally provides no such indicator. Before the exposure, you may get a range indication. However, the range indicator doesn't tell you the specific distance setting.

With some cameras, you may have to rely on checking the focus at the film plane. Fortunately, there's often an easier test technique. The Minolta AF2, as you've seen, has seven focus positions. You can determine which position the lens has selected after you remove the film-speed ring and filter ring (the rings at the front of the lens assembly).

Now, as you release the shutter, you can see a slider move along a contact board, Fig. 77. As the lens moves in, the slider swings counterclockwise. The position at which the slider stops indicates the distance setting of the lens.

Minolta even marks the seven focus positions on the contact board. If you locate the target one meter from the film plane, the slider should stop at position 1, Fig. 77—the closest-focus position. For a target at infinity, the slider should stop at position 7, Fig. 78.

At a distance of 1.27m, the slider should stop at position 2. The slider should stop at position 3 at a distance of 1.47m, position 4 at 2.1m, and position 5 at 2.35m.

The accuracy adjustment also depends on the system. With a sweeping-component system, the accuracy adjustment may change the angle of the sweeping component—the mirror in a passive system or the IRED in an active system. The adjustment in a nonsweeping system normally changes the angle at which the light strikes the infrared detector.

In the Minolta AF2, a mirror directs the reflected infrared light to the infrared detector. The accuracy adjustment then changes the mirror angle. You can reach the accuracy adjustment at the top of the AF module, Fig. 75.

The accuracy adjustments in the Visitronic system move the scanning mirror. However, adjusting the Visitronic system requires voltage measurements—it's necessary to balance the voltage outputs of the two light sensors.

Sweeping-component systems, such as the Visitronic and Canon AF35M systems, can't be adjusted by simply replacing a module. Even with a new autofocus module, it's necessary to make the adjustments. And, since voltage measurements may be required, we won't discuss the specific adjustment procedures at this point in your program. As mentioned earlier, though, a nonsweeping system normally is supplied as a complete module—preadjusted at the factory. The preferred adjustment technique may then be to simply replace the complete AF module.

TEST-YOURSELF QUIZ #5

1. You're checking a Minolta AF2 with a target located one meter from the camera. When you push the release button part way, you get the mountain symbol in the finder. This indicates
   A. an error in the infinity adjustment
   B. an error in the accuracy adjustment
   C. a defective electromagnet
   D. a defective autofocus module

SYSTEM IS NOT CHOOSING PROPER SUBJECT DISTANCE

2. You're checking the adjustments in a camera using the Visitronic system. When you cover the autofocus windows and release the shutter, the distance indicator moves to the infinity position. But the customer's complaint is that his pictures of distant subjects aren't sharp. This indicates
   A. an error in the infinity adjustment
   B. an error in the accuracy adjustment
   C. a defective electromagnet
   D. a defective autofocus module
3. An adjustment on the autofocus module that horizontally shifts the AF frame provides an adjustment for
   A. infinity focus
   B. accuracy at finite distances
   C. selectivity
4. A white circle or bar pasted on a matte-black target provides a good selectivity test target for
   A. cameras using the Visitronic system
   B. cameras using the infrared system

SUMMARY

SUMMARY

You've now covered the types of rangefinders used in most of the current rangefinder cameras. Before the single-lens reflex became so popular, there was more variety in rangefinder designs. However, if you are working on older rangefinder cameras, you should be able to relate the principles to those you've studied.

Most of the rangefinders you'll be repairing are movable-lens systems with cam-and-lever linkage. The movable lens sits between the beamsplitter and the fixed 45° mirror. As you turn the focusing ring of the lens, the cam-and-lever linkage shifts the position of the movable lens with respect to the base line. Then, at the proper distance setting, the movable lens causes the secondary image to superimpose on the primary image.

In a cam-and-lever linkage system, the cam corrects the rangefinder for finite distances. The amount of lens movement required to focus at different distances isn't linear. For example, the lens moves a relatively large distance in changing the focus from 2 feet to 3 feet—a focus change of 1 foot. But the lens moves a small distance in changing the focus from 15 feet to 30 feet—a focus change of 15 feet. The cam changes the nonlinear movement to a linear rangefinder movement.

Some earlier rangefinder systems use rotating wedges with geared linkage. Changing the gear timing then provides your accuracy adjustment. With cam-and-lever systems, the accuracy adjustment is usually on the rangefinder linkage, the movable lens, or the 45° mirror.

Quite often, the rangefinder has adjustments both for infinity and for finite distances. The linearity adjustment for finite distances corrects for errors in the cam shape. Normally you should avoid disturbing the linearity adjustment. Just make the adjustment for infinity.

The rangefinder also has an adjustment for vertical alignment of the images. Usually the vertical-shift adjustment tilts the 45° mirror to shift the secondary image up or down. The vertical-shift adjustment does not affect the rangefinder accuracy. So, when you make the adjustment, the target distance makes no difference.

Each rangefinder design you've studied projects a duplicate image into the finder. Such designs are called "superimposed-image rangefinders." A few of the older cameras use split-image rangefinders. Here, the rangefinder optically splits the subject in half. The lens is in focus when the two image halves align. You'll still see the split-image principle used in the focusing aids for single-lens reflex cameras.

If you're working on older press cameras, you might also encounter rangefinders that are mounted vertically—rather than horizontally—to the camera body. The adjustment for infinity then aligns the images vertically. And the vertical-shift adjustment becomes a horizontal-shift adjustment.

You've seen that the rangefinder detemines the subject distance by calculating the unknown side of a triangle. Most autofocus systems work the same way. In this lesson, you've covered some of the autofocus systems used in the relatively inexpensive 35mm cameras. Here, the lens moves slightly beyond the closest focus distance as you cock the shutter. When you release the shutter, a spring draws the lens toward infinity. The autofocus system stops the lens at the proper distance setting.

There are two basic types of autofocus systems. The passive system uses ambient light to determine the subject distance; it makes a brightness (or contrast) comparison of two subject views. An active system supplies its own distance-seeking output—usually a beam of infrared light. The infrared light reflects from the subject and returns to an infrared detector in the autofocus system.

In some active systems, the infrared light sweeps across the field of view as the lens moves toward infinity. But most of the current infrared systems use a stationary source of infrared light. Such systems determine the subject distance when you push the release button part way to power the circuits. The nonsweeping system has an advantage in that it can provide an error indication—it can tell you in advance if the subject will trick the autofocus system.

The adjustments in autofocus cameras depend on the particular system. But you normally have an adjustment for infinity, a selectivity adjustment, and an accuracy adjustment for finite distances. The infinity adjustment changes the position of the lens with respect to the focus ring. The other adjustments affect when the autofocus system stops the rotation of the focus ring.

With a sweeping-component system, you may have to make the autofocus adjustments. But a nonsweeping system may be designed for modular replacement. If the system doesn't properly set the focus, you can simply replace the AF module.

ANSWERS

ANSWERS TO TEST-YOURSELF QUIZZES

QUIZ #1

1. You view the **primary** image directly through the viewfinder; the **secondary** image is projected optically into the viewfinder.
2. A
3. A
4. decrease (see Fig. 9)

QUIZ #2

1. A
2. C
3. A
4. B
5. frame-line mask

QUIZ #3

1. 600
2. 600 times 50mm equals 30 meters. The distance is then satisfactory for a 50mm lens or a 35mm lens. For the 135mm lens, however, the distance should be at least 81 meters (600 x 135mm).
3. A
4. B
5. C
6. C
7. D
8. A
9. C
10. Set the vernier caliper to a setting that equals the **base length** of the rangefinder. The distance between the vernier and the rangefinder makes no difference.

QUIZ #4

1. An autofocus system that uses an infrared LED is an **active** system. An autofocus system that relies on ambient light to determine the subject distance is a **passive** system.
2. A
3. C
4. A
5. A
6. C
7. C (the matte-black subject absorbs all of the incident infrared light)
8. B (no infrared system can focus on a matte-black subject)

QUIZ #5

1. D
2. A (the autofocus is setting the proper position, but the lens moves in too far or not far enough to provide sharp focus at infinity)
3. C
4. B